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GRASSLAND IMPROVEMENT

INSECTICIDAL LACQUERS AND WHITE COFFEE-BORER CONTROL

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EARTH-EATING AND THE MINERAL NEEDS OF LIVESTOCK

THE COTTON RED BOLLWORM PROBLEM IN SOUTHERN TANGANYIKA

EFFECTS OF PUCCINIA POLYSORA RUST ON YIELD OF MAIZE

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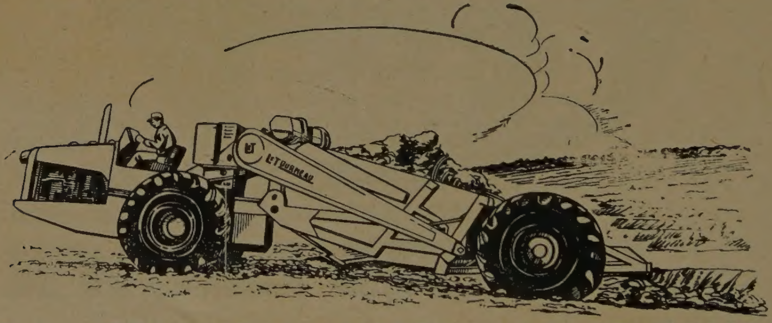

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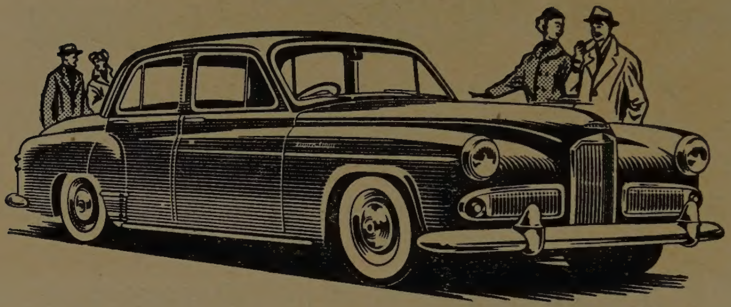

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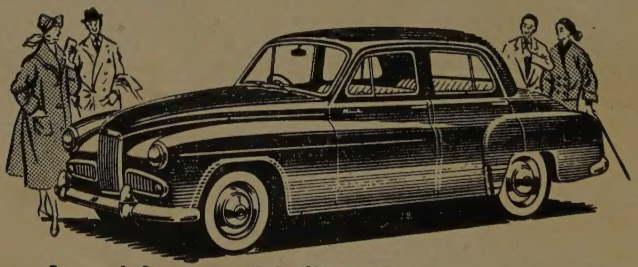

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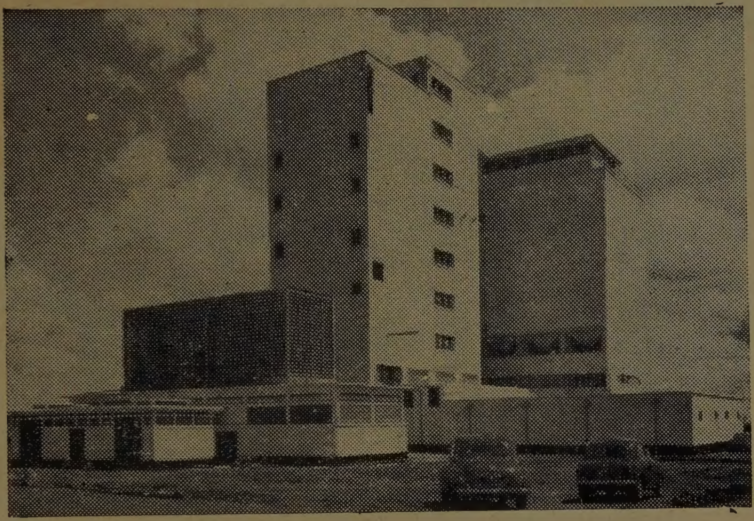

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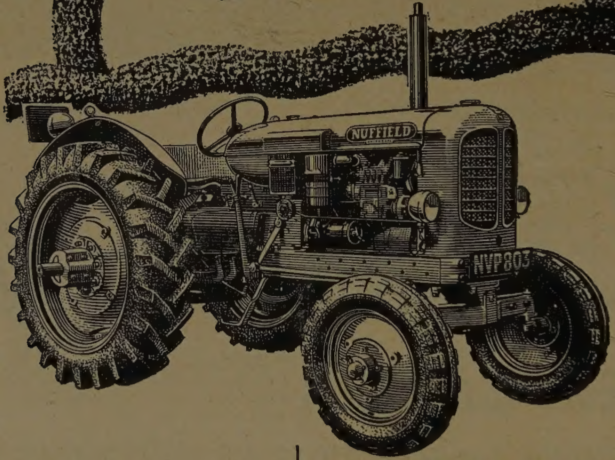

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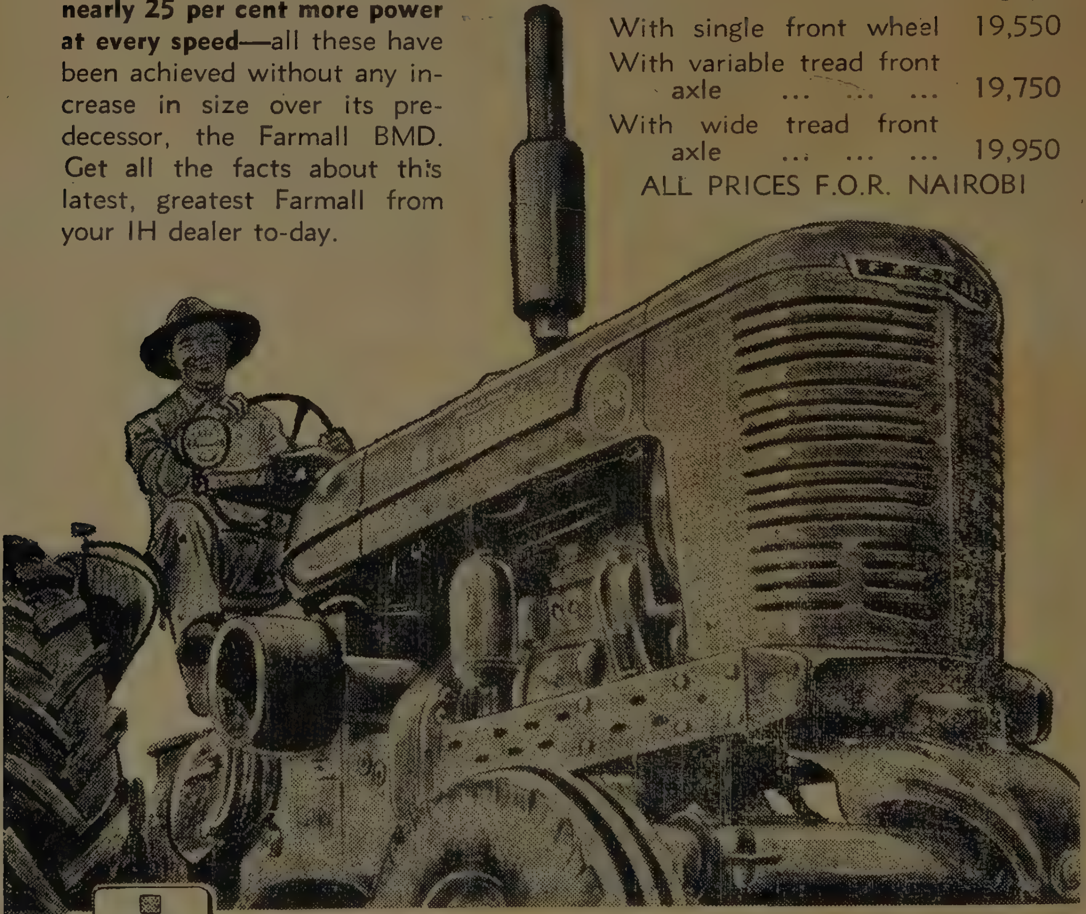

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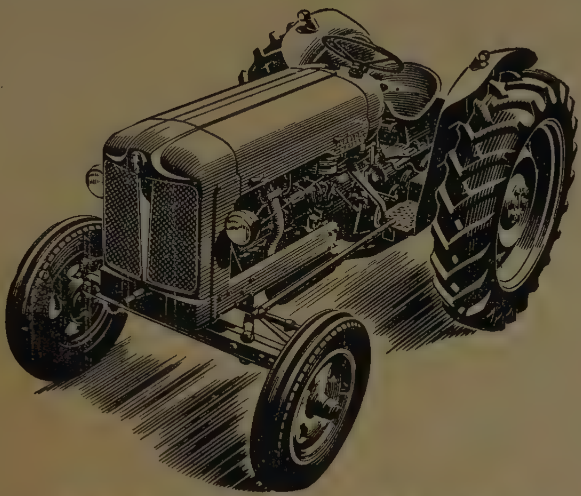

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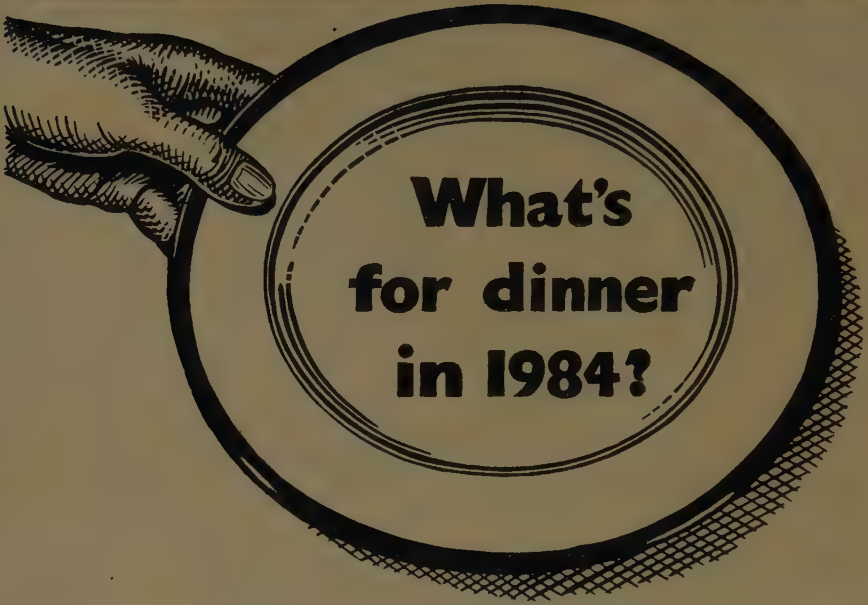

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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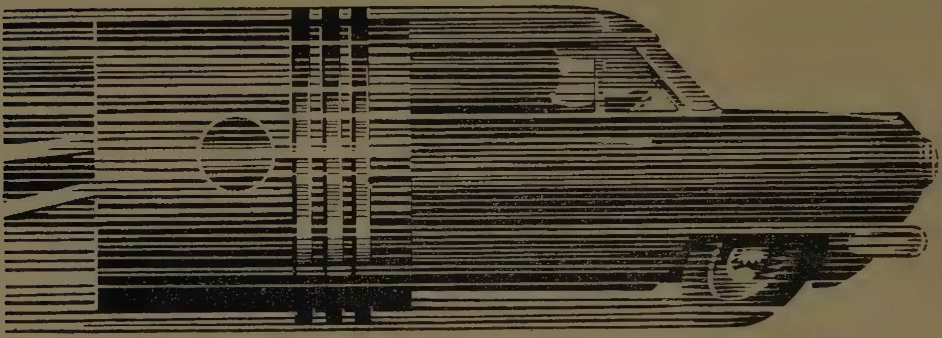

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GRASSLAND IMPROVEMENT

Pasture research is of vital importance in the agricultural development of most countries, and it is of interest that the world progress in this subject has been summarized in a book entitled *Improving the World's Grasslands**. Much of the information is of direct interest to farmers in East Africa, and the following notes have been abstracted from the book.

The world's grassland area is much greater than its area of arable land but its yield is much less. The Netherlands is exceptional in that its grassland yield equals in fodder units that of the land devoted to cereals, but much of the world's grassland farming is still pure plundering. It has been argued that there is considerable competition between man and livestock for the products of arable land, but at least four-fifths of the total feed in the world eaten by livestock consists of roughage, hay, stover, and silage, which are not suitable for human food. But the experience of farmers and research workers is that nutrients for livestock feeding can be produced more cheaply in grassland crops than in grain crops, the proportionate costs being grazing 100 per cent, hay 140 per cent, silage 187 per cent, dried grass 294 per cent, concentrates 314 per cent.

In the tropics, the rainy season supplies an abundance of herbaceous forage, but in most areas of heavy rainfall the soil is so poor, and plant food becomes available so slowly, that the growth in two or three months becomes coarse, unpalatable, and unfit for a maintenance ration. Consequently, unless it is economical and feasible to make hay or silage of such grass before it becomes mature, the animals must be moved to better pastures, depend on browse, or starve to death. A point which is sometimes overlooked is that, in general, cattle have a limited appetite for low-protein diets, so that their feed intake decreases on poor pastures. A trial at Cornell University showed that cows ate their full capacity of 150 lb. per day of green grass only when they were on a dense well-grown sward. When the food supply became more difficult for these animals to gather they ate much less, and well below their normal capacity. In Trinidad, Duckworth found that the average daily consumption of fresh elephant grass by dairy cows was only 51 lb., and of elephant grass silage only 46 lb. These quantities are only one-third to half as great as the quantities of green grass commonly eaten by similar cows in the temperate zone. A 1,000-lb. dairy cow would need to eat nearly 65 lb. a day of elephant grass to supply her requirements of digestible protein for maintenance, and nearly 100 lb. a day to supply her maintenance requirements for total digestible nutrients.

The problem of adjusting the rate of grazing to the growth habits of plants is complicated by the varying rate at which plants grow and produce forage for animals. This is particularly marked in the tropics, but even in the Netherlands it was found that a typical pasture grows at a rate which will carry 1.6 cows per acre in May and June, 1.3 cows in July, 1.2 cows in August, 0.9 cows in September, and 0.8 cows in October. On rangelands of low fertility in humid areas of the temperate zones and the tropics, the grass is such poor quality that the animals will not eat it or cannot be maintained on it after it becomes mature. Such grass should be eaten off, in so far as is practicable, during the growing season. For the balance of the year, the animals require other feed such as hay, silage, browse, and natural or cultivated pastures on good soil which produce forage such as leafy legumes that are nutritious when mature. Even on good soils in the tropics, the stems of the coarser and heavier-yielding grasses, such as guinea grass, become too woody for cattle to eat. Such grass should be eaten about as fast as it grows, as long as it is kept about one or two feet high, depending on the species.

In India a study was made of the nutritive value of the leaves, stems, and whole plants of elephant grass at heights ranging from one to six feet. It was concluded that between three and four feet is the most economic height for utilizing this grass as harvested fodder. On the better soils in the tropics there are some grasses, such as sugar cane, which remain green during the long dry season of 4–6 months and can be fed as *soilage* (freshly cut green feed) when pastures are too dry to be of any use. Even in temperate climates there may be a marked difference in yield according to the height at which grass is grazed; one experiment in the U.S.A. showed that brome grass grazed to keep the forage two to three inches tall produced only 54 per cent as much as when it was cut at the hay stage, but another plot grazed at six to ten inches in height produced 90 per cent as much as when cut at the hay stage.

---

* *Improving the World's Grasslands*, by A. T. Semple, F.A.O. Agricultural Studies No. 16, 1951. Obtainable from Leonard Hill, Ltd., 9, Eden Street, London, N.W.1. Price 10s. 6d.

In the higher rainfall areas of the tropics and subtropics the chief aim of rotational grazing is to keep the grass from maturing. This is done most effectively by rotating three paddocks at short intervals such as one week. By such a system, cattle are kept from losing weight for three or four weeks longer at the end of the growing season. But intensive grazing interferes with the storage of plant nutrients in the roots for the next year's growth, so it is necessary to have a fourth paddock in order that one can have a complete rest during the growing season. Since the growth of this paddock is worthless for feed, it should be mowed for compost or burned off if it is not practical to mow it.

Range areas which are grazed throughout the year, or for periods much longer than the growing season, should not be grazed closely. At the end of the growing season the important and palatable plants should have had only as much of their herbage removed as they can withstand while remaining vigorous and maintaining satisfactory production. Then, enough stubble should be left at the end of the grazing period to give adequate protection to the grass crowns and to check wind or water erosion.

The yearly yield of forage may vary from 40 per cent above the average to 30 per cent below it; thus a rancher trying to keep enough cattle to consume the average production of forage would in some years have only two-thirds as much production as needed and in other years would have two-fifths more than needed. Ranchers should plan to keep about enough animals to use the average yield, then, in years when forage production is below normal, they can sell their young animals earlier, before they begin to lose weight, and cull the breeding animals more closely, thereby reducing the load on the grass. It is necessary to watch the amount of rainfall, the moisture condition of the soil, and the condition of the plants, in order to tell when the forage supply is running below normal and threatening to become inadequate for the season. In years of high production young stock can be left longer and the annual culling of the breeding stock may be less severe than usual. An excess growth of grass means that more seed is matured, and the greater amount of mature grass uneaten increases the mulch on the soil surface; some of the grass can be harvested for hay.

In places where the excess forage is mainly woody and unpalatable, it is undesirable that these species should be allowed to mature and to shed seed. The pasture should be mowed before the unwanted grasses have formed seed; burning at maturity may be advantageous in some areas. The burning of grassland is a practice about which there is a great diversity of opinion, and it must be kept in mind that the need for burning may be the result of long-continued overstocking which has killed off the more palatable grasses and left only those which are coarse and unpalatable. On the other hand, burning may improve the pasture appreciably, and it is pertinent to quote D. C. Edwards' observations after a ten-year study of the effects of burning in the acacia-tall grass savanahs of East Africa, where the rainfall varies from 20 to 30 inches annually:—

1. The dominance of red oatgrass (*Themeda triandra*), a desirable indigenous forage grass, is strongly favoured by burning. It readily survives fires because the corkscrew-like awns, by alternately moistening and drying, drive the seeds about one inch deep in the soil. Some studies in South Africa show that fires affect the soil to a depth of only 0.2 inches.
2. *Digitaria abyssinica*, a weed, largely replaced red oatgrass where large quantities of herbage had collected during eight years of protection from fire. The extremely coarse wiregrass (*Pennisetum schimperi*) can also be suppressed in favour of *T. triandra*.
3. Fire is a necessity for grazing on the most extensive grasslands of East Africa, but certain steep slopes and catchment areas should be protected, returning such areas to bush or forest.
4. Grazing areas should be burned during the dormant season, after the bulk of grass seed has ripened; and they should be burned only every second or third year where there is not much accumulation of old grass.

The invasion of pasture and rangeland by noxious weeds, shrubs, trees, and poisonous plants is one of the most difficult and troublesome problems with which graziers have to deal. Hand clearing is so expensive that specialized mechanical equipment has been designed, such as tree dozers, root cutters, brush cutters, and brush beaters, while heavy disk ploughs and heavy duty mowers are also used. The prickly pear was eradicated in Australia by biological means, and a great deal of experimental work is now being carried out on chemical methods of killing plant pests. Some weeds can be eradicated by applying fertilizers to the land in order to encourage the growth of the more desirable species, but this requires caution, since the principle is that the new soil conditions should be unfavourable to the undesirable plants.

Where rainfall is a limiting factor in plant growth, all practical means should be used to economize it. On some heavily grazed pastures as much as 45 to 70 per cent of heavy rains may be lost by runoff; on the same vegetation, lightly grazed, only 10 per cent is lost. Thus two or three times as much water may go into the soil to make continuing growth possible when the grass is grazed down to a height of three or four inches as when it is grazed down as closely as the animals can bite it off. In areas of low rainfall and sudden storms the pitting of pastures has had a marked effect. Shallow pits are made about five inches wide and four inches deep at intervals of two to five feet. A one-way disk harrow is used, with every other disk removed, those remaining being mounted off-centre on the shaft so that they cut one oval-shaped slice from the soil in each revolution; 30 to 50 acres can be pitted in a day with a 10-ft. disk harrow. This pitting process thins the vegetation by approximately one-third, provides more moisture and plant food for the remaining plants, and greatly stimulates their growth. It has also been used in re-seeding range pastures, since competition with other plants is reduced, a good seedbed is provided for the young plants, and the pits hold sufficient water to give the young seedlings a good start.

The species of grass best suited for each particular soil and climate is a matter for trial and error, but the results are sometimes striking. For example, subterranean clover from the Mediterranean region, where it is of minor importance, has become of great importance in southern Australia, where it has increased the yield of forage by 200–300 per cent, and has made possible the conversion of worthless land into very valuable pastures. Much work is being carried out in many parts of the world in searching for exotic species which will give higher yields or better feeding values than the indigenous grasses.

The chief difficulty in extending the use of a grass species which has proved its value is that of obtaining viable seed in quantity. The methods of grass seed production are quite different from those used with cereal crops, and each herbage plant has its own peculiarities. The treatment of seed after harvesting may also be important, since some seeds that are highly impervious to moisture must have their hulls treated mechanically or chemically, and others must be put through a hammer mill to break off appendages which would interfere with their passage through a mechanical seeder.

Good pasture management must include adequate supplies of drinking water, spaced so that the animals can utilize all available grazing in rotation without having to walk long distances for water. Ideally, none of the grass should be more than half a mile from water, but on a range of low carrying capacity it is usually not economic to space watering places more than five miles apart on level or gently rolling land, or more than one mile apart on very rough land. Sheep should not have to travel more than three or four miles to water in cool weather, or more than one and a half to two miles in warm weather. Obviously, animals with young need drinking places more closely spaced than those without. In windy areas, animals tend to graze into the wind, so it is better to have watering places nearer the leeward side of the paddocks, where they are least inclined to graze and to congregate.

Shade is a very important factor in the efficient production of livestock, and should be provided in all pastures where air temperatures in the open are nearly as high or higher than body temperature (100°F) during the hot part of the day. If trees or bushes are not available it pays to erect artificial shelters.

The knowledge required for good stock management has been summarized by J. W. Rowland as follows: "We know, because the animals feed every day, there must be a continuity of flow of animals' feed from herbage, whether from natural growth, or pastures, or crops, or all three. The greater the improvement in the type of livestock, the greater is the skill needed to provide a satisfactory flow of feed. Critical knowledge is required of what the pasture, range or veld can do; when the top growth of pasture plants can be removed with the least damage to root growth and root reserves, which are essential for the continued life and effective performance of the plants during the remainder of the current season and during the seasons to come; the potentialities of different pasture and range types as annual, temporary, or permanent grazing, or as hay crops; the sequence of pastures throughout the year; and the correct use of available supplements from arable land. The working of this flow of feed into a system—in which the animals are moved from field to field through the seasons with an easy margin of sufficiency and with experienced assurance of the capacity of each ley and forage unit—is one of the most fascinating studies in farming".

D. W. DUTHIE.

NOTES ON ANIMAL DISEASES

Compiled by the Department of Veterinary Services, Kabete, Kenya

VIII—Foot-and-mouth Disease*

(*Received for publication on 15th November, 1954*)

Foot-and-mouth disease is a febrile, infectious disease characterized by the appearance of vesicles in the mouth, on the feet or, less commonly, on other parts of the skin.

ETIOLOGY

In 1897, Loeffler and Frosch, studying this disease, passed lymph from infected animals through a Berkefeld filter and produced the disease with the filtrate, thus demonstrating for the first time a so-called filterable virus as the cause of disease of animals or man. The virus may be kept for long periods in 50 per cent glycerine in the refrigerator, and it has been proved also to survive in the bone marrow and other tissues of carcasses prepared for market. Recently, workers at Pirbright have revived the virus in tissues that had been stored for 13 years in a deep freeze. Virus, dried on hay or bran or other materials, may retain its infectivity for four or five months provided it is not exposed to high temperatures or strong sunlight.

As with certain other viruses, more than one type of foot-and-mouth disease virus exists, each being immunologically distinct. Prior to about 1946 the so-called classic virus types were the "O", "A" and "C" viruses. Since that date, however, it is recognized that in Africa, notably in the southern African territories, the virus also exists in three other separate and distinct types, to which the description has been given S.A.T. I, S.A.T. II and S.A.T. III. The disease has occurred in Mexico and South America in recent years, and also in Canada, in all of which countries the viruses responsible, though not classic pure strains, belonged to either the "O" or "A" groups. Unfortunately, outbreaks occur due to certain so-called variants, which when first identified in the field do not belong to any one of the recognized pure types mentioned above, although in some cases they settle down, as it were, under experimental examination and appear eventually as "O" or "A" or "C". The significance of these types of variants is that the immunity arising from infection or vaccination with any one does not normally protect against any of the others. A further difference in these types and strains is their variation in infectivity. Normally in Europe the disease is one of the most highly infectious known, being transmitted even to animals in buildings or on grazing recently vacated by infected stock, through the movement of infected foodstuffs or manure, or even by farmers or other persons visiting infected premises, then moving to uninfected farms carrying the virus on their boots, clothing or by other means. Another odd feature of the disease is the way in which it often creeps steadily across country for many miles and may then suddenly jump 10 or 15 miles or more to strike at a new farm. Recently it has proved to the satisfaction of most authorities in England that the large flights of starlings which are an annual feature of bird movement from the continent of Europe are responsible for bringing the virus of foot-and-mouth disease from the Low Countries, and possibly the north of France, to the south-east corner of England.

Normally in the tropics the disease is of lower infectivity than it is in Europe, and most outbreaks in Kenya can be attributed to the direct contact of infected and healthy stock. In England it has been proved that rats and hedgehogs may suffer true foot-and-mouth disease, showing lesions on the pads of the feet, and these animals are incriminated in the spread of the disease. Information is sought upon the possibility of rodents or other animals in Africa acting in a similar way; the porcupine may yet be proved to be a source of infection.

SPECIES SUSCEPTIBLE

In nature the disease affects ruminants and swine primarily. Cattle and pigs are highly susceptible, sheep and goats considerably less so. So far the disease does not appear to have been confirmed in wild ruminants in Kenya, but it has been demonstrated in kudu and impala in Southern Rhodesia, in deer in

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* This new article on foot-and-mouth disease replaces a former article in this series published in this *Journal*, Vol. 6, No. 2, October, 1940.

Northern America (in 1924), and, in a severe epizootic which raged in South Africa towards the end of the last century, the reports stated that large numbers of all ungulates suffered from the disease, many fatally.

Until recently the guinea pig was the only satisfactory laboratory animal for study of the disease, but more recently it has been found that the virus can be maintained and will multiply satisfactorily in unweaned mice, thus providing an extremely convenient laboratory animal for research purposes.

Foot-and-mouth disease is believed to occur also in man, infection resulting either from the consumption of milk from infected cows or from the direct contamination of cuts with the virus. The most characteristic symptoms are headache, fever and occasionally blisters or vesicles in the mouth. Other animals such as equines and canines are not susceptible.

INCUBATION PERIOD

The incubation period following natural infection in stock is usually from two to seven days, but may be as long as 17 days.

SYMPTOMS

The disease commences with a rise in temperature which during the first 24 to 48 hours may reach 105° F. Once vesicles develop the temperature usually falls. Vesicles may form in the mouth or on the feet or, less frequently, they appear on the udder, the nasal mucous membranes, and in the air passages. The presence of lesions in the mouth leads to difficulty in chewing. The animal eats slowly and salivates profusely. A smacking sound made by the lips is a characteristic sign. Lesions on the feet cause lameness which may persist for several weeks.

In indigenous African cattle the lesions may be very difficult to see and are very often only erosive in character. Wherever they form in more susceptible stock the vesicles begin as small blisters containing a watery fluid which later becomes cloudy. The vesicles rupture leaving isolated, red, raw sores varying in size up to two or three inches in diameter. In the mouth they are usually found on the front half of the tongue, frequently quite close to the tip, but they may be present on the insides of the cheeks or on the gums. After two or three days the raw surface becomes covered with proliferating epithelium with a fairly definite firm margin, and if healing is normal the lesions are completely resolved in a few weeks. Often, however, the injured mucous membrane is invaded by bacteria, such as the necrosis bacillus, or pus-producing organisms, and a yellow or brown ulcer may then persist for many weeks. Lesions on the feet are to be found between the claws, around the top of the hoof and especially towards the heels. One or all feet may be affected. If the lesion occurs between the horny and sensitive structures, separation of the hoof may follow. From their position lesions on the feet are particularly susceptible to secondary infection by bacteria and this is one of the causes of greatest loss in heavy bulls.

On the udder, vesicles usually occur on the teats and in the milk ducts. The milk becomes thick and yellowish-white in colour. The local lesions of foot-and-mouth disease lead usually to marked general symptoms. There is a heavy loss of condition, and even if the udder is not directly involved the milk yield of lactating cows drops severely and may not be fully restored during that lactation. Attacks in which general symptoms are mild do occur in Kenya and it has been suggested that virus from such outbreaks should be preserved with a view to its being used for the preventive inoculation of cattle when grazing conditions are favourable. There is, however, no reason to suppose that a virus isolated from a mild outbreak would continue to produce a mild disease in cattle as and when required. In fact, samples of lesion material, which are often extremely difficult to collect from African cattle, if used on pedigree stock or sent to England and tested there in highly susceptible stock usually produce the very severe lesions of Europe. Young calves frequently die suddenly without showing any lesions in the mouth or on the feet. Death in these peracute cases is due to degeneration of the heart muscle and although there has been considerable discussion as to the cause of these lesions it seems probable that it is due to the direct action of the virus which is present in the circulation during the temperature reaction.

POST-MORTEM LESIONS

The characteristic lesions found on post-mortem are those of the mouth and feet already described above, and in addition the following changes may be present:—

A varying amount of congestion or ulceration in various parts of the alimentary tract, swelling of the spleen, hæmorrhages on the heart sac and other serous membranes, pneumonia and, in rare cases, swelling of the joints with ulceration of the joint membranes. In calves which die suddenly the heart muscle has a characteristic dry, white appearance.

COMPLICATIONS

Several complications are liable to follow an attack of foot-and-mouth disease. Secondary infection of the sores in the mouth and feet has already been mentioned. Lesions in the windpipe may lead to pneumonia, and those in the udder to mastitis or the formation of abscesses. Abortion is frequent. In heavy bovines, particularly pure-bred bulls in Kenya, an infection due to *Corynebacterium pyogenes* may develop in a small group of muscles, usually on the posterior limb. This may not be noticed until a month or so after the animal has apparently recovered. A further peculiar condition is development of a woolly coat. This condition, which persists for several years, is most frequently observed in Kenya in high-grade cows. Affected animals are bad doers, they pant heavily after exertion, and, in many cases, show an inability to breed or an interference with the normal breeding cycle. It is peculiar that these woolly-coated animals are practically never seen in southern Africa.

MORTALITY

Mortality from foot-and-mouth disease in cattle and sheep is usually low, and the economic importance of the disease lies in the loss of condition and milk yield. For example, in 1952 in western Europe it was considered that the loss due to the foot-and-mouth disease outbreak of that year was in the region of £3,000,000. Mortality from the disease may be high in calves and also in pigs. In Africa losses may be heavy in times of drought where grazing is rough and of low nutritional value, and when the animals may have long distances to trek to water.

TREATMENT

No drug with any specific chemo-therapeutic action on the virus has as yet been discovered. Many claims have been investigated in different parts of the world, including Africa, but so far there has been no scientific proof of any effect upon the virus, although secondary infection may often be overcome very quickly and the effects of the disease thus minimized if drugs such as the sulphonamides are used. Affected cattle should not be moved farther than is absolutely necessary, and when possible they should be left to their own devices on green grazing with easy access to water. The reservation of a couple of small paddocks close to a river as sick paddocks is one of the most useful improvements that can be made on farms in the dry districts of East Africa. Such paddocks will be found invaluable for the treatment of sick animals at all times. During times of drought supplementary feeding may be necessary. Green fodder crops are to be preferred but in their absence a small ration of concentrates may be helpful. Silage is very useful in these circumstances. Lesions may be treated with an antiseptic lotion, while the usual remedial measures for feet disinfection are advised where feet lesions are common or troublesome, i.e. application of stockholm tar, foot baths or sulphonamide therapy.

CONTROL

The first necessity in undertaking control at the present time is, if possible, to type the virus in question. Fresh tongue lesion material should be obtained from natural cases, preserved suitably in 50 per cent glycerine buffer phosphate solution in tightly sealed bottles kept cool and out of the sunlight, and submitted to a typing laboratory. The Animal Virus Diseases Research Institute in Pirbright, England, is the world centre for typing, and prepares freeze-dried sera which can be used under certain circumstances in a complement fixation laboratory test for identifying the classical strains of virus mentioned above. Under fully satisfactory conditions an answer may be obtained in as little as 48 hours from the time of arrival of the sample at the laboratory, but in many cases the material has to be revived by passage through baby mice, or even in cattle, before it is of sufficient value for use in such tests, and this may occupy many days or even several weeks. If the outbreak is due to one of the classic types, "O", "A" or "C", vaccination is possible, as described later.

The successful control of foot-and-mouth disease under African conditions depends largely on the so-called invasiveness of the particular virus causing any one outbreak. This is a factor which is difficult to describe, but invasiveness varies in the rapidity with which the disease spreads, in the percentage of animals on any premises which succumb to the disease, and in the propensity of the disease to jump several miles to start new outbreaks.

With indigenous or low grade stock it was often the practice in the past to hasten the outbreak by deliberately spreading the disease to all cattle in infected herds, thus shortening the time during which the disease is present in the herd. Virus from the vesicles of a natural case was collected on cotton wool or lint and rubbed firmly on the mucous membrane of the mouth of uninfected animals. Chances of spread to other parts of a large ranch or to neighbours were greatly reduced by the short definite period of vigilance required. In southern Africa, notably the Rhodesias, the current practice is to carry out an intramuscular injection of the field virus into all cattle within an isolated area surrounded by police cordons. The success of the method, of course, depends upon the concentration of cattle to be infected into a suitable area, and upon the creation of a surrounding stock-free zone which is usually some five to 10 miles in extent. There are few parts of Kenya which lend themselves to action of this sort.

Where the strain of virus is of low infectivity, and circumstances on the farm are favourable, fairly simple measures may be successful in preventing the spread of infection. Healthy animals should not be allowed to come in contact with sick or recently recovered animals, nor should they pass over the same ground nor use the same watering places. The movement of African employees should be controlled, and the owner should inspect the healthy herds before, and not after, any visit to the infected groups. Transport animals should not pass between the two parts of the farm; motor vehicles are less dangerous and easier to disinfect.

For general disinfection of buildings and feeding utensils the best disinfectants are a 1 per cent solution of caustic soda or of formalin, or a 4 per cent solution of Magadi soda. The first solution, of course, should not be used for disinfecting hands, clothes or foodstuffs as it is corrosive and poisonous.

In a country like Kenya where the disease is endemic (i.e. always present more or less in some part of the territory), the slaughter policy could not be expected to control the disease. This policy has been most widely adopted in Britain, largely because of its geographical island separation, and a few brief figures may be of interest in this connexion. In 1869 the disease was made reportable. In 1871 there were 52,000 outbreaks reported, affecting over three million head of stock. Between 1880 and 1884 there were over 27,000 outbreaks reported affecting 800,000 head of cattle. In 1892 power was given to the authorities to apply the slaughter policy. From 1892 to 1922 there were never more than 95 outbreaks in any one year. In 1922 and 1923, however, there was a most serious outbreak which severely tested the slaughter policy. In these two years there were nearly 3,500 outbreaks in which the animals slaughtered totalled nearly a quarter of a million head of cattle, sheep, and pigs, for which a total compensation of almost £3,000,000 was paid. For a period after this, hyper-immune serum was used as a method of control, being given to cattle on neighbouring farms though not on infected premises, but it was eventually abandoned in favour of slaughter and destruction of all infected and contact stock. Since 1940 healthy carcasses from infected farms have been salvaged after a close inspection at a chosen abattoir. This was begun as a war-time measure to save meat, and has been continued as experience proved it to be safe, using the meat only in the large towns.

VACCINATION

For some years vaccines against foot-and-mouth disease have been used on the continent of Europe, and there have recently been important improvements in the methods of vaccine production. In the Danish, Swiss and German institutes tongues are harvested from slaughtered cattle in order to prepare the vaccine, but in the Amsterdam Institute a method of tissue culture involving the use of stainless steel vats has been developed, thereby considerably reducing the number of tongues needed. In all the continental vaccines the virus is absorbed on aluminium hydroxide, and is then treated with formalin and incubated at 37°C. for 48 hours. Such vaccines are considered to be entirely safe, in that they will not set up active disease nor will vaccinated animals transmit the disease to susceptible stock with which they may come in contact. The foot-and-mouth vaccines must be kept at a temperature of between 2° and 6°C. at all times, in order to avoid any loss of potency. The vaccine is injected subcutaneously into the area of the dewlap, or into some other convenient site, where it develops a small if unsightly lump. Immunity develops 12 to 14 days after vaccination, and persists for anything from four to eight months, depending upon the type of virus from which the vaccine was prepared.

Attempts have been made to incorporate two or even three of the classical types of European virus in one vaccine, but some experiments have suggested that this is not always satisfactory. One strain of virus in such a multiple vaccine may be suppressed during the development of immunity, through what is known as interference, and as the slower strain may fail to develop there may arise a false sense of security in the mind of the stockowner, and a failure to control foot-and-mouth disease should an outbreak due to the suppressed type of virus occur.

The effective use of foot-and-mouth disease vaccine requires that the type of virus responsible for any outbreak should be known before the vaccine is used, since a vaccine prepared from the "O" strain of virus will protect only against that strain, and not against other virus types. No vaccines are yet available from the institutes on the continent of Europe against the S.A.T. types of virus, and none of these institutes is willing to attempt this work for fear of an escape of the South African viruses among their local cattle. Should these S.A.T. strains of virus be encountered in Kenya the use of vaccines prepared in Europe is unlikely to achieve any control of outbreaks caused by such strains.

Attempts have been made at Kabete and at Pirbright to prepare a crystal violet vaccine, using the blood of cattle infected with the S.A.T. strains. Unfortunately, these virus types showed considerable irregularity in their ability to produce a satisfactory vaccine, and the work has been suspended for the time being.

The widespread use of vaccines in Mexico and on the continent of Europe has shown that vaccination by itself cannot be considered as a successful means of eradicating foot-and-mouth disease. In the Mexican outbreak even four vaccinations did not prevent the disease from reappearing and sweeping once again across the country. In France during the period September, 1951, to September, 1952, more than six million cattle, sheep and goats were vaccinated and yet there were 314,605 outbreaks affecting more than five million ungulates during that period. In the United Kingdom in the same period there were 570 outbreaks affecting only 35,000 stock, which were slaughtered.

From this it should be clear that the most that can be expected of vaccination in Kenya, during the next few years, is that it may reduce, and in some cases prevent, the financial loss which would arise from outbreaks in dairy herds. Judicious use of vaccine may perhaps enable the Veterinary Department to suppress minor outbreaks, and to prevent, when circumstances are favourable, the invasion of the European settled areas by outbreaks originating in African areas. There is, however, little likelihood that the widespread use of vaccine on the European farms will significantly reduce the number of outbreaks of foot-and-mouth disease in the Colony as a whole.

INSECTICIDAL LACQUERS AND WHITE COFFEE-BORER CONTROL

By **R. G. Tapley, Department of Agriculture, Tanganyika**

(*Received for publication on 13th August*, 1954)

It has been shown [1] that, if certain insecticides, particularly dieldrin, are applied to stems of coffee trees immediately before the beetles emerge, a good control of beetles and a fair control of ring-barking larvæ can be obtained. It has been found, however, that a considerable amount of the insecticide is absorbed by the bark and therefore presumably less available to beetles, although to some extent available to ring-barking larvæ [2]. It has been considered that if the insecticides could be deposited on the bark without being absorbed they would be more efficacious against the beetles. Wettable powders may be less readily absorbed by the bark, but it was thought that they would be more readily washed off by rain.

A search for a formulation which would be held on the surface of absorbent bark and yet not easily dislodged by rain, was without result until the writer's attention was drawn to new insecticidal lacquers [3] during a visit to the Colonial Insecticide Research Unit, Porton, England. These lacquers, also known as U.F. coatings (U.F. = Urea-formaldehyde resin), were said to be active for long periods, possibly two years or more. It was decided to test the coatings against the white coffee-borer in Tanganyika.

INSECTICIDAL LACQUERS

The resin base was:—

Urea Resin BC 666	200 gm.
Alkyd Resin BC 555	300 gm.
Nomanol	37 gm.
Solvent 15/9c	88 gm.

Four insecticides were added separately to 625 gm. of this resin base, to give the four insecticidal lacquers used in the test; these were:—

Dieldrin	50 gm.
DDT	100 gm.
Aldrin	50 gm.
Gamma BHC (lindane)	25 gm.

These mixtures are colourless, but to assist application and observation a white pigment was also included giving the preparation the appearance of a white paint*.

Immediately before application, 32.5 c.c. of an acid accelerator consisting of: 1.5 c.c. concentrated sulphuric acid, and 31 c.c. butanol, was added to the mixtures.

The physical properties of these formulations are unique. Immediately after spraying and after hardening they impart a glossy finish. As soon as the surface is disturbed mechanically, even by very slight pressures caused by insect movement, small, sharp erect insecticide crystals, which are deadly to insects, bloom through the surface. If these crystals are rubbed off others soon appear. In this way the glossy surface soon becomes mat. While crystals are readily broken off by insects rain does not appear to wash them away.

Once bonded in the resin nothing can separate the insecticides from their base, even in the laboratory. Consequently the formulations are active for long periods; in the holds of ships and on the seashore the insecticidal effect has been said to persist for two years and more.

The lacquer must be applied in the field by paint sprayers operating at 40 lb. per sq. in. and with an output of 9 cu. ft. air per minute; in this way a thin, even coat can be obtained. Application by brush is slow, generally unsatisfactory, and wasteful.

EXPERIMENTAL DATA

Phytotoxicity.—No signs of phytotoxicity have been noted either to stems or to foliage when applied as a spray. When it is applied by brush leaves show signs of scorch, but the stems are unaffected. This is perhaps surprising considering the preparation contains ½ per cent sulphuric acid. These observations have been made in the laboratory on seedlings and on over 200 trees in the field, some of which received exceptionally heavy doses.

Laboratory Tests.—Extensive laboratory tests were not made. Glass plates were sprayed with each lacquer and borer beetles were placed on each under glass dishes. Blooming was observed on both dieldrin and DDT plates soon after the beetles were introduced. No blooming has ever been observed on BHC and aldrin plates and this may be due to the volatile nature of the insecticides.

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* The four insecticidal lacquers were specially prepared by Messrs. Burt, Boulton & Hayward, Crabtree Manorway, Belvedere, Kent, England.

The plates were exposed to rain (and artificial rain) which did not induce blooming nor wash off existing crystals.

Beetles exposed for a few hours on aldrin and BHC died within 24 hours of exposure; beetles exposed to DDT and dieldrin died after 48 hours. These death rates are similar to those obtained from the same insecticides in different formulations.

Field Experiments.—The stems of single stem coffee trees were quickly cleaned of loose bark, soil, and mosses, from soil level to about 18 in. up the stem. Batches of trees were later lightly sprayed with DDT, dieldrin, BHC, aldrin and nil insecticide lacquers respectively on 10th March, 1953. Rates of application were about $\frac{1}{2}$–$\frac{2}{3}$ gal. per acre. A few borer beetles, all that were available, were introduced into stem cages which were placed on one tree from each treatment and good kills were obtained in each case. A second batch of trees was similarly treated and sprayed on 16th December, 1953. At that time large numbers of beetles were available and a series of observations was made.

Stem cages, approximately 12 in. by 12 in. by 12 in., were clamped on one treated stem of each of the plots and control. Clean fresh branches and foliage were placed in the cages. Six female beetles and six (or as many as were available towards the end of the series) males were introduced into each cage and left there for 48 hours. The beetles, if they showed any signs of life, were then placed in recovery cages, with clean coffee stems and foliage, for a further 48 hours.

Each cage was then placed on another tree of the same plot, and more foliage and beetles introduced. In this way a series of six trees sprayed in March was tested and four of the trees sprayed in December. It was not possible to test trees No. 11 and 12 of the December spraying as supplies of beetles became exhausted.

In each case the numbers of dead, moribund and living insects were noted after 48 hours in the field and 48 hours in recovery cages. The number of eggs was estimated without actually disturbing the bark. About three months later (30th March, 1954) the trees were examined for living larvæ.

A summary of the results obtained is given in the Table I. If a beetle showed any signs of life after 48 hours in the recovery cages it was counted as "living". Completely moribund insects were considered to be dead.

Conclusions from these results were as follows:—

(1) Both DDT and dieldrin lacquers give a good control of the female beetles a few days and eight months after application.

(2) BHC lacquer gives a poor kill after eight months' exposure, but a good kill of the beetles while it is still fresh on the tree.

(3) Aldrin lacquer gives a poor and erratic kill both after short and long exposures in the field.

(4) Control, lacquer only, does not in itself affect mortality of the beetles.

(5) Insecticidal lacquers do not prevent oviposition. Lacquer alone does not seem to affect very much the number of eggs laid. The number of eggs laid appears to be inversely proportional to the mortality rate of the beetles.

(6) In the cases of DDT, BHC, aldrin and control, the ratio of mortality of ring-barking larvæ compared with the estimated number of eggs laid seems to be similar, but this is not confirmed statistically because of high standard errors. Dieldrin consistently gives high mortality.

It was noted in each case that almost all the eggs laid in the trees hatched out normally into ring-barking larvæ. The ring-barking stage usually lasts until three months from egg-laying when the larvæ enter the wood. At the time the trees were examined for larvæ almost all had in fact entered, or were about to enter, the wood. They were therefore given every chance to come in contact with insecticide in the bark. In the case of dieldrin-treated trees the burrows in the bark were very short: the larvæ had picked up lethal doses in the early stages. Mortality in the control trees was due in part to parasite activity. Mortality with DDT, BHC and aldrin was almost certainly due in part to the insecticides, but the burrows in which dead or no larvæ were found were consistently bigger than the burrows in the dieldrin treated trees.

It is not fully understood why the dieldrin lacquer gave such an excellent kill of larvæ. Later tests showed that minute quantities of all lacquers did reach living tissue by capillary action in the bark fissures. Presumably the small amount of dieldrin coating which penetrated the bark was sufficient to destroy the larvæ.

Experimental Error.—In this experiment, as with many borer control experiments, considerable experimental error has been encountered. This makes statistical analysis difficult to apply, and therefore it is not always possible to speak of results as being "significant" in the statistical sense. The main factor which gives rise to error in this assay is the lack of standard insect material. With a long and variable life history it is not practicable to breed up standard material. Therefore all experiments of this nature must depend on material collected in the field, and this is usually damaged. Collection of beetles is necessarily left to children under supervision of laboratory assistants and almost every beetle is injured to a lesser or greater degree. Those beetles with a portion of an antenna or a tarsus missing are regarded as being suitable for test provided they are active, while those with greater injuries are rejected. Unfortunately it is not possible to detect internal injuries unless a beetle is showing obvious signs of distress.

Another difficulty is that the insects, confined in cages, fight very aggressively. Therefore in a cage with a capacity of 1 cu. ft., which is a suitable size for this experiment, not more than six females can be included at the same time. Hence the number of insects that can be tested at one time in a tree is limited. Increased replications could be obtained by increasing the number of cages, but it has been found that two assistants can only move about 12 cages per day without making errors.

Another source of experimental error is climate. Some of the beetles were exposed to rain while being tested on the trees while other batches encountered hot sun. These conditions are, of course, normal in the field, but add to the difficulties of the assay.

In this experiment, therefore, a compromise of ideals and practicabilities has had to be made and must be borne in mind when the results are considered and conclusions made.

Costs.—Ten per cent dieldrin lacquer costs about Sh. 80 per gallon in 5-gallon drums landed at Tanga. This includes the cost of the accelerator. Since the lacquer must be applied by a paint sprayer this will put up costs. A suitable sprayer costs about £160. It has yet to be determined how many acres per day can be sprayed by one machine with a crew of two.

Future Work.—A compressor and paint sprayer have been ordered and 40 gallons of 10 per cent dieldrin lacquer. Twenty-five acres of coffee will be sprayed in a statistically planned experiment, and as much coffee as possible will be sprayed as observation blocks, mostly on young non-infested coffee in heavily infested areas.

Other applications.—Insecticidal lacquers may be useful in other spheres. A food safe which was constantly infested with ants and other insects in spite of "ant-proof" shoes was sprayed nine months ago with 20 per cent DDT lacquer and is still free of all insects. It has been suggested in a private communication that insecticidal U.F. coatings should act as a repellent to rodents in buildings even if the floors only are treated. Other possible applications in East Africa which come to mind are for pest control in kitchens, food stores, bakeries, and grain-storage buildings. They may also be suitable for ant-banding coffee trees.

SUMMARY

Ten per cent dieldrin in a synthetic lacquer has given exceptional results in both the control of borer beetles and ring-barking larvæ. The preparation was sufficiently active after eight to nine months of exposure to sun and rain to give an 83 per cent kill under the conditions of the experiment as described, compared with a 3 per cent and 14 per cent mortality in the control. Another feature is that dieldrin lacquer was consistently effective against ring-barking larvæ which shows that it was residual for at least nine to ten months after application.

So far these are the most promising results ever obtained in preliminary tests of this nature, and the results fully justify field trials on a considerable scale. It should be of a greater use on Kilimanjaro than at Arusha, since on Kilimanjaro borer-beetles can often be found in varying numbers for six to eight months of the year, and it is considered that the effectiveness of dieldrin emulsion is bound to break down long before that period is over. Moreover the lacquer formulation shows promise of being effective for much longer periods. At Arusha on the other hand, beetles are present for a shorter period of four to eight weeks only, and it is known that dieldrin emulsion is fully effective for that time.

ACKNOWLEDGMENTS

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TABLE I.—RESULTS OF EXPOSING BEETLES AND RING-BARKING LARVAE TO INSECTICIDAL UREA-FORMALDEHYDE COATINGS

Date Trees Sprayed	Tree Number	Date Beetles introduced	D.D.T.			DIELDRIN			B.H.C.			ALDRIN			CONTROL: LACQUER ONLY			CONTROL: NO LACQUER		
			I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
10–4–53	1	11–12–53	5	5	4	5	4	1	4	6	1	0	11	2	0	12	5	0	8	(All extracted in February for other purposes)
	2	14–12–53	4	8	4	2	10	0	1	7	6	3	6	5	0	13	9	0	19	
	3	16–12–53	6	6	6	6	9	0	2	11	4	5	8	5	0	16	7	2	15	
	4	18–12–53	5	12	10	5	4	0	2	5	4	1	20	7	0	26	8	1	22	
	5	21–12–53	5	4	3	6	13	0	0	28	4	0	18	9	1	4	6	0	16	
	6	23–12–53	6	9	2	6	12	0	1	8	8	2	12	7	0	21	11	2	8	
16–12–53	7	28–12–53	4	4	2	4	3	0	6	5	0	4	14	4	2	3	3	1	22	
	8	30–12–53	5	0	0	6	2	0	6	4	2	3	7	0	1	10	6	1	14	
	9	2–1–54	6	3	3	6	4	0	6	6	0	5	8	0	0	19	11	0	16	
	10	4–1–54	5	7	4	6	16	0	6	3	0	0	5	2	0	11	10	0	12	
		TOTAL ..	51	58	38	52	77	1	34	83	29	23	109	41	4	135	76	7	152	

Column I—Number of beetles killed after 48 hours exposure in the field and 48 hours in recovery cages. Six females introduced each time.

„ II—Estimated number of eggs laid in the treated trees by the beetles during the 48 hours exposure.

„ III—Number of living larvae observed in the respective trees, 12-13 weeks after egg-laying.

NUTRITIVE VALUES OF FEEDING-STUFFS

By M. H. French and A. Rogerson, Joint Animal Industry Division of
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With the establishment of the Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O. at Muguga, one of the problems with which this Division will be concerned will be the determination of the feeding values of a number of East African animal fodders and concentrated foods. Many common foodstuffs in Tanganyika have already been reported upon and the results have been summarized [1]. This earlier work with cattle, sheep and pigs inevitably omitted many animal foodstuffs which are commonly used in East Africa and was truncated by wartime emergencies before it had dealt adequately with the wide range of local grasses, hays and silages. The resumption of this work with sheep at Muguga will enable many gaps to be filled and will be complementary to work on similar lines and with the same objectives in other territorial stations, such as the digestibility studies being undertaken with oxen at the Entebbe laboratory in Uganda. Although there is much to be done on the evaluation of local feeding-stuffs, it is confidently expected that unnecessary and unfortunate overlapping in this work will be effectively prevented by discussions at the various Interterritorial Committees and by the interchange of visits and information between the workers involved.

Digestibility trials have been carried out in a number of countries during the last 100 years and during this time there have been many improvements in techniques, methods of analyses and in the procedures for calculating and expressing nutritive values. The procedure to be adopted at Muguga will be to conduct the standard digestibility trials with two or more sheep with single or mixed foods. The experimental animals will be adequately housed in crates within the main laboratory and fed known amounts of weighed foodstuffs. To facilitate the separate collections of urine and fæces, only male sheep will be employed. They will be suitably harnessed to enable the collections to be made without loss, and the crude protein and dry matter will be estimated in the wet fæces daily. Composite samples of food and excreta will be prepared for detailed analysis over a 12-day collection period, following an initial preliminary interval during which the animals will be able to settle on the rations and reach a fairly balanced state between their intakes and excretions. Standard methods will be followed for calculating digestibility values, and analytical procedures will follow those accepted by a sub-committee of the East African Specialist Committee on Animal Industry. The latter are, of course, accepted procedures, the crude fibre being estimated by the Wende method as prescribed for the United Kingdom [2] and nitrogen will be determined in micro-quantities in the Markham apparatus after suitable dilution of the material following the normal Kjeldahl digestion.

Feeding values will be calculated by Kellner's method [3] from the digestible nutrients using Kellner's proportionate deductions for fibre contents. Where a concentrated foodstuff is under study and recognized Value numbers (V) have been adopted elsewhere for comparable foodstuffs, the Value number employed by Woodman [4] will be used. It is, however, felt most strongly that until more information is available locally, the feeding values of grasses, hays, silages and other local fodders should not be calculated by the V numbers of comparable British foodstuffs. The reason for this view lies in the more fibrous nature of many East African fodders and the fact that the digestible crude fibre often exceeds the total quantity of digestible N-free extractives.

The latter raises the problem of what is estimated by the standard crude fibre method, particularly as there is a loss of lignified material during its estimation. Work will be focused on this problem and on the possibility of estimating digested energy-forming nutrients by calorimetric methods but, until a clearer picture is available, the Kellner procedure will be used in published work.

Commercial farmers are constantly pressing for information on the feeding values of the more common local grasses at various stages of growth. It is relatively easy, although time consuming, to determine the feeding values of conserved fodders such as hay and silage, because the preserved material is of fairly uniform composition and is unlikely to change during the course of an investigation. It is not so simple to determine the feeding values of actively growing grasses, because during the time taken to conduct the preliminary feeding and the actual trial, a total of three–four weeks, growth does not cease and the result is that there is a marked difference in maturity and development between the beginning and the end of an experiment. In temperate areas, this point can be overcome to a large extent by cutting the herbage daily at a predetermined point so that all grass fed is of the same age and consequently of a more uniform degree of maturity. Even if the procedure of pre-cuts is employed in East Africa, the rainfall varies considerably during the subsequent growth periods so that marked differences are reached in the maturity of the successive daily rations fed. It is also true that most areas, where grasses are grown locally, have not been under cultivation or free from bush sufficiently long for the soil conditions to have become uniform between the sites from which roots have been dug and the intervening spaces. The result is that markedly different pockets of fertility exist in the recently developed fields, and these, combined with the pronounced variations in rainfall and temperature, suggest that a different technique must be employed locally. Experiments are planned to overcome these problems but, until a successful local technique has been developed, it seems premature to conduct expensive and time-consuming digestibility trials on growing fodders knowing that the results must always lack precision.

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HERBAGE PLANTS AT THE GRASSLAND RESEARCH STATION, KITALE, KENYA

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The object of this account of the plant introduction work at the Grassland Research Station is to survey the field which has been covered, and to indicate which the most promising species are, apart from the more well-known ones which have been extensively tested or come into agricultural use already.

Where species are already under widespread trials, or in general use, the investigations and tests are directed towards finding better strains than those being used at present. For example, in Rhodes grass, Molasses grass, Star grass and Elephant grass, there is great scope for improvement. In the case of pasture legumes, some species have been selected for field scale trials, but many improvements in their characters are desirable. There is a big field available for the selection of fodder legumes, and the selections now made need to be critically compared in field experiments.

It seems unlikely that plant introduction and nursery work will come to an end or be completed in the foreseeable future. This is because of the vast amount of material still remaining from which selections can be made, and to the fact that the quality, production, disease resistance and adaptability of types now in use will need to be improved as time goes on. Another factor of great importance in Kenya is to obtain strains which are well adapted to local conditions, in view of the wide variation which occurs in altitude, temperature, length of rainy season, and soil fertility, and whether a locality has one or two rainy seasons in the year. The testing of new species and strains, both indigenous and introduced, is thus an important part of the work of the Grassland Research Station at Kitale.

Climatic conditions in the Colony vary from the almost temperate climate of the Highlands, with occasional frosts, to the tropical conditions in the coastal area, and also from a humid climate with about 100 inches of rain per annum, to semi-arid conditions, with a low rainfall and intense heat and evaporation.

The number of plots in the nursery in 1953 exceeded 1,500, which included different species and strains from Kenya and other countries, including fodder grasses, pasture grasses, and also fodder and grazing legumes, and from this material it is hoped to meet the herbage plant requirements of many of the important mixed farming areas in Kenya.

Kenya itself provides a fruitful source of material, with not less than 450 species of grass, many of these existing in the forms of numerous ecotypes and strains, and an even greater number of legumes. Of the plants which are already in cultivation in Kenya, such as Rhodes grass and Molasses grass, or show promise, such as Guinea grass, *Brachiaria brizantha* and *Cenchrus ciliaris*, numerous varieties and strains are under preliminary tests in the nursery, some of which already seem to be better than the commonly cultivated varieties.

The nursery was started in 1951 by Mr. L. R. N. Strange, and taken over by the author in 1953. Numerous samples of seed have been received from the Plant Industry Station, U.S. Department of Agriculture, Beltsville, Maryland, and from the Division of Plant Industry of the Australian Commonwealth Scientific and Industrial Research Organization, Canberra. From Kenya, apart from collections made by the Pasture Research Staff, a great deal of material has been received from Mr. S. P. Rawlins. To these, and numerous other contributors, we express our sincere thanks.

The Kitale Grassland Research Station is situated in the western part of Kenya, at an altitude of 6,200 ft. The soil of the area is a brownish sandy loam, pH 5 to 6, and the natural vegetation is represented chiefly by *Combretum* woodland, which, due to periodical grass fires, acquires an open, orchard-like character with species of *Hyparrhenia* dominating in the grass cover. The mean rainfall is 46 in. per annum; most of it falls during the rainy season which lasts from the beginning of April to September or October, frequently with a few weeks' break in May, or more usually, June, and with the dry season from October or November to March. In 1953, the rains were slightly less intensive than usual but lasted longer, and in October and November an appreciable amount of rain was recorded. The grasses, therefore, remained green very late, many of them up to the end of the year. The seed harvest also lasted longer than usual, and was only completed in February, 1954.

In 1953, the nursery included over 1,500 plots, which were of two standard sizes, smaller plots, 6 by 6 ft., for the first introductions, and larger plots, 15 by 15 ft., for further study of the more promising grasses and legumes. Every year many species and strains are rejected and discarded, and replaced by new samples. None of the plots received fertilizers in 1953.

Apart from numerous species of which one or a few varieties were grown, the following more important grasses and legumes were represented by a number of types of different origin: *Chloris gayana,* Rhodes grass (41 samples); *Melinis minutiflora,* Molasses grass (21); *Brachiaria brizantha,* Signal grass (44); *Cenchrus ciliaris,* African Fox Tail (36); *Panicum maximum,* Guinea grass (47); *Setaria sphacelata* and *S. trinervia* (51); *Setaria splendida* (20); *Cynodon dactylon,* Star grass (39); *Cynodon plectostachyum,* Naivasha Star grass (10); *Pennisetum purpureum,* Elephant grass (17); *Glycine javanica* (17); and *Trifolium semipilosum,* Kenya White clover (16).

GRASSES

MOLASSES GRASS

All samples of Molasses grass cultivated in the nursery belong apparently to *Melinis minutiflora* Beauv. The type known as *M. maitlandii* differs only in having hairy spikelets. In a few plots an entirely different form, with non-viscous leaves, apparently *M. ambigua,* occurred as an admixture to the main type.

Twenty-one samples of Molasses grass grown in the nursery showed a wide range of variation in vigour, leafiness and in habit. They also varied in hairiness of the spikelets and in the length of the awns. The following numbers were the best:—

K.53608, from Nigeria. Leafy and vigorous.

K.51321, from Rongai. Leafy and vigorous.

K.52294, from Kitale—commercial. Vigorous, but only of medium leafiness.

K.53144 from U.S.A. Late form, leafy and vigorous.

The first generation progeny of four distinct forms of Molasses grass was tested for uniformity. The progeny seems to be uniform and true to the parent plants so far. The seeds for the test were produced in the nursery where a number of varieties were grown within a small area, but no mixed forms were observed in the first generation.

GUINEA GRASS (*Panicum maximum*)

Forty-seven varieties of *Panicum maximum* cultivated in the nursery showed a wide range of variation in vigour and leafiness, and they can be divided into the following groups:—

(*a*) Tall, vigorous type. Robust plants with large leaves and rather thick stems. A fodder type of high productivity. Usually late in development.

(*b*) Var. *trichoglume* type. Plants of medium vigour, with numerous fine stems. Leaves numerous, rather broad and short (lanceolate). Basal and stem leaves are both numerous. Mainly a grazing type.

(*c*) Medium-size type with narrow, predominantly basal leaves, Usually stemmy, although occasional good leafy forms occur in this type.

(*d*) Annual type. Only one sample of this was observed. The plants, of good leafy type, produced seed and then died in August.

Although the majority of forms cultivated in the nursery produced large numbers of fertile stems and panicles, the amount and the quality of the seed was not satisfactory. The following factors affected the seed production:—

(*a*) Many seeds shed before ripening.

(*b*) Many seeds eaten by birds.

(*c*) Fungus diseases on spikelets.

(*d*) In the majority of spikelets the caryopses were not formed and the spikelets were empty. This was probably connected with the weather conditions during flowering.

The following varieties showed encouraging results:—

K.52125, Lilongwe strain, obtained from the Belgian Congo. Outstanding in leafiness and vigour. Flowering stems were scarce and seed production poor.

K.52129, from Mackinnon Road. Leafy and vigorous. The plants did not produce seed in 1952 and only occasional flowering heads were observed in 1953.

K.52436, from South Africa. Leafy and vigorous, with numerous panicles.

K.52518 and K.51285, both from West Suk (Kenya). Leafy and vigorous, with numerous panicles.

K. 5374, from Australia. Leafy and vigorous. Late flowering type.

Of the *trichoglume* variety, the following ones produced leafy, attractive growth:—

K.53838, from Rumuruti.

K.5377, from Australia.

K.50201, from Australia.

Of the smaller type with narrow leaves, K.53530, from Mombasa, produced a dense, leafy sward and numerous panicles.

RHODES GRASS

Rhodes grass varieties differed considerably in vigour, leafiness, sward density and types of stolons. Some varieties produced a dense and low cover very early, and only then began to form flowering stems. Others formed flowering stems before the ground was covered. Two types of stolons were observed and while some varieties produced relatively few large stolons with long, thick internodes and rather large leaves, the others had finer stolons with short internodes and smaller leaves. The varieties with fine stolons usually produced a denser network of stolons and a denser sward, but were less vigorous. Of the 41 varieties cultivated in 1953 the following showed good results:—

K.5068, from Kapenguria escarpment. Outstanding sward density.

K.50198, Nzoia strain. Leafy and vigorous, but less stoloniferous and with an uneven sward.

K.50198A, from Cherangani. Rather similar to the Nzoia strain; slightly more vigorous.

K.50193, from Endebess. Formed a good, dense, leafy sward.

K.51246, from Chepararia. Vigorous and dense in the sward.

K.53107, from West Suk. Leafy.

K.53166, from Uganda. Leafy and dense in the sward.

K.53611, from Nigeria. Outstandingly stoloniferous and dense in the sward. Not vigorous.

K.52364, from Kabarnet. This variety, which originates from a dry country, resembles the Rongai type of Rhodes grass but is more stoloniferous and leafy.

SETARIA SPECIES (*Setaria splendida, Setaria sphacelata and Setaria trinervia*)

These three closely allied species of *Setaria* can be distinguished by the vegetative characters better and more easily than by the spikelets, and it may perhaps be that they belong to the same large and variable species. *S. splendida* is more vigorous and has large broad leaves. The shoot-bases are broad and flat. *S. sphacelata* is less vigorous with less flattened shoot-bases. *S. trinervia,* which is usually still less vigorous, has cylindrical shoot-bases.

Setaria splendida.—Twenty samples are under cultivation and they represent mostly clone or group selections from a few varieties obtained in 1950 and 1951 from Tanganyika. The following leafy and vigorous varieties seem to be the best of them: K.51128, K.51130, K.51132, K.53763 and K.53768.

S. sphacelata and S. trinervia.—Of 51 varieties and clones, the following showed good results:—

K.51150A2 and K.51150B, clones of Nandi *Setaria* (originally from Baraton, Nandi Kenya), which are vigorous and leafy.

K.53828, from Equator, Kenya, an erect and leafy form.

K.5185, from Cherangani, a vigorous and leafy erect form.

A few samples of Kazungula *Setaria,* which apparently belongs to *S. sphacelata,* produced tall and vigorous plants, but they were rather stemmy.

In 1953 nearly all varieties of *Setaria sphacelata, S. splendida* and *S. trinervia* were badly attacked by bunt (*Tilletia echinosperma*). The disease appeared, however, later in the season and the plants which flowered in May and June had mostly healthy spikelets.

SIGNAL GRASS (*Brachiaria brizantha*)

Brachiaria brizantha is very variable and several varieties showed striking differences in habit, leafiness, vigour, hairiness, seed-setting capacity, etc. Prostrate and semi-prostrate forms seem to be more suitable for grazing, but they flower less abundantly than some of the erect and stemmy types. Many varieties produced numerous panicles and spikelets, but as a rule only a small proportion of the spikelets contained caryopses. Poor seed production may be attributed mainly to the weather conditions at the time of flowering and to diseases and pests. Some varieties were much more susceptible to the spikelet diseases than others. The first generations of several distinct varieties planted in 1952 were quite true to the parent plants and although the seeds were collected in the nursery from adjacent plots no mixed forms were observed.

In 1953 the following numbers of *Brachiaria brizantha* produced attractive leafy growth:—

Prostrate types: K.52418, from West Suk; K.52320, from Kitale.

Semi-prostrate types: K.53834, from Rongai; K.52305D, from Mpwapwa, Tanganyika; K.52318, from Kitale; K.51366 from the Belgian Congo; K. 52309, from Tanganyika; and K. 53835, from Rongai.

AFRICAN FOX TAIL (*Cenchrus ciliaris*)

Cenchrus ciliaris occurs naturally in the areas which are drier than Kitale and the evaluation of varieties under Kitale conditions can only be approximate. Although the majority of the varieties cultivated in the nursery were tufted perennials some forms had short rhizomes and formed slowly spreading colonies. Rust on the leaves and smut on the spikes of many varieties were observed in 1953.

Of 36 varieties grown in the nursery the following showed some promise:—

K.5146, from Kabete. Low, leafy and dense in the sward.

K.53378, from West Suk. Semi-erect, vigorous and leafy.

K.5148, from Kabete; K.53125, from Tanganyika, K.52528, from West Suk and K.5133 from Nairobi, were tall, vigorous and leafy.

Two varieties from India were very small, weak and unproductive.

STAR GRASS (*Cynodon dactylon*)

Thirty-nine varieties cultivated in the nursery were of the following main types:—

(*a*) Vigorous types with thick stems and stolons and with large, robust, harsh leaves.

(*b*) Medium-sized types with less thick stems and stolons. The most promising leafy varieties belong mainly to this group.

(*c*) Fine types with thin stems and stolons and with fine, rather small leaves. The herbage of this type usually has a large proportion of stems and is less palatable.

Nos. K.51424, K.51426, K.51431 and K.51447, all originating from Kitale, showed the best sward quality. No. K.51426 produced numerous spikelets with well-developed caryopses and is a promising seeding variety. Other varieties with fairly good seeding qualities did not produce good herbage.

NAIVASHA STAR GRASS (*Cynodon plectostachyum*)

This species occurs naturally in the low and dry areas of Kenya and Tanganyika, and at Kitale it is out of its normal environment. Nevertheless, two out of ten varieties cultivated in the nursery showed good results. They were:—

K.52424 from Kamasia. Outstanding in vigour and leafiness, but with poor seeding qualities.

K.52350 from Magadi area. Rather stemmy, but showed outstanding seed-setting capacity, producing a good yield of seed with well developed caryopses. At Kitale the spikes of this variety were badly infested with smut.

Two other varieties of *C. plectostachyum* also showed fairly good seeding qualities, which in this species are generally better than in *C. dactylon.*

ELEPHANT GRASS (*Pennisetum purpureum*)

A collection of 17 varieties was cultivated in the nursery. As most of the varieties were established only in 1953 and the plants were not cut for silage, only preliminary observations were carried out. The varieties differed in vigour, leafiness, hairiness and in the formation of flowering heads. One from the Cameroons and one from Kabete seem to be better than the rest.

INTRODUCED TROPICAL GRASSES

Eragrostis abyssinica, Teff grass. (Ethiopia, cultivated).—A slender annual which grew very fast and produced the first crop of seed a few weeks after planting. After harvest it developed new panicles and produced a second crop. The grass was weak and required much weeding.

Leptochloa virgata (India).—Rather small, semi-erect tufted perennial. The grass seeded well but did not show promise for grazing or fodder, as it grew slowly and lacked vigour.

Panicum antidotale.—Vigorous, tall, stemmy tufted perennial with wiry stems. Seed production was good. Four samples of different origin showed similar results.

Paspalum commune (Argentina).—Tufted perennial of less than medium vigour. Generally poor.

Paspalum dilatatum (S. America).—A perennial which produced broad and low vigorous tufts, and formed a dense leafy sward. A few varieties grown in the nursery were almost identical. The grass is already in cultivation in some countries, and deserves extensive trial in Kenya at medium and high altitudes.

Paspalum humboldtianum (America).—Tufted perennial which developed very slowly and produced small tufts without flowering heads.

Paspalum malacophyllum (S. America).—Tufted perennial which formed dense and fairly tall foliage and numerous flowering heads. Seed production was satisfactory. A promising grass for further trial.

Paspalum paniculatum (S. America).—This grass produced small and weak tufts without flowering heads. Poor.

Paspalum pauciciliatum (Argentina).—This grass developed slowly and produced low, dense tufts of medium vigour. It resembles *P. dilatatum*, and is generally fairly good.

Paspalum plicatulum (America).—This grass produced low, broad tufts with wide leaves. Although rather slow, it developed an attractive form and deserves further study.

Paspalum regnellii.—Tufted perennial which formed a dense cover of broad leaves one foot in height, with numerous flowering heads. An attractive grass which deserves further trial.

Paspalum secans (W. Indies).—Perennial which forms small, semi-prostrate, rather stemmy tufts with hard and crisp leaves. Generally poor.

Paspalum setaceum (America).—Tufted perennial with dense foliage 6–8 in. in height and numerous flowering heads. This grass deserves further trial.

Paspalum simplex (S. America).—Tufted perennial which developed very slowly and formed prostrate weak tufts. Poor.

Paspalum stramineum (N. America).—Tufted perennial which grew very slowly and formed small, weak tufts with broad, short leaves. Poor.

Paspalum urvillei (Central Africa).—Strong tufted perennial. It was planted from roots, and developed large leafy tufts with the herbage about 1 ft. in height, and tall flowering stems. This grass showed a marked edge effect and apparently requires moist and fertile soil. Generally good.

Pennisetum haareri (Tanganyika).—Perennial forming slowly spreading tufts provided with short rhizomes. The tufts are tall and dense, with numerous thick hard stems. This grass is too coarse for use as fodder.

Pennisetum pedicellatum (Tropical Africa).—An annual which grew rapidly and developed dense, leafy herbage 18 in. high. Seed was well produced. May be of use as an annual fodder or pasture plant and deserves further trial.

Pennisetum subangustum (W. Africa).—Very similar to *P. pedicellatum.*

Saccharum officinarum.—Fodder Sugar Cane. Tall and vigorous tufted perennial of the Elephant grass type. The grass is intended for trial on swampy ground. On the dry soil of the nursery the tufts were vigorous but rather stemmy.

Setaria vaginata (S. America).—Tufted perennial which formed small, semi-prostrate and unproductive tufts.

Snowdenia polystachya (= *Beckera polystachya*). (Ethiopia).—This plant has been known in Kenya under the name of Abyssinian grass and was often confused with *Beckeropsis uniseta.* Was occasionally cultivated in Kenya, at rather high altitudes. In the nursery it developed quickly and produced a leafy growth 2–3 ft. high. Most of the plants died after producing seed, but some plants remained green long into the dry season. Seed production was good. May possibly be used at high altitudes as a quickly growing fodder plant of short duration.

TEMPERATE GRASSES OF EUROPEAN AND AMERICAN ORIGIN

Agropyron cristatum, Crested Wheat Grass.—Tufted perennial, of which three samples were planted. It developed very slowly and towards the end of the season formed weak tufts with the leaves lying flat on the ground. No flowering heads were produced.

Agropyron desertorum.—Tufted perennial very similar to *A. cristatum.* It formed slightly more vigorous tufts and towards the end of the growing season produced occasional spikes. This, and *A. cristatum*, originate from a very dry country, and should be tried at lower altitudes.

Bouteloua gracilis.—Tufted perennial which was planted in 1952 from roots. In 1954 the tufts were small, very dense, with numerous fine leaves and short flowering stems. Should be tried further under drier conditions.

Bromus inermis, Brome Grass.—It germinated well and grew rapidly during the first two months of the rainy season, but later in the season the growth slowed down considerably. Produced medium-sized tufts without flowering heads. A sample of this grass planted from splits produced larger tufts of which a few formed single flowering stems. Apparently unsuitable for Kitale conditions.

Dactylis glomerata, Cocksfoot.—The seed germinated well but the seedlings developed slowly and formed only small, weak tufts. A sample planted in 1952 had larger tufts with occasional panicles. The grass looked unhealthy and is apparently unsuitable for Kenya conditions.

Festuca elatior, Tall Fescue.—A few samples planted in 1954 developed very slowly and produced small tufts without flowering stems. A sample of the Kentucky "31" Fescue planted in 1952 formed fairly large tufts and produced panicles. The grass suffered from drought during a dry spell in May and was generally much poorer than the same strain grown at higher altitudes.

Festuca pratensis, Meadow Fescue.—A few strains of various origin were planted. Nearly all of them germinated well but most of the plants died at an early stage. The remaining formed small, slowly growing tufts and did not produce any flowering stems.

Lolium italicum, Italian Rye Grass.—The grass was planted late in the season, germinated well and formed medium-sized, leafy tufts. Flowering stems were not produced.

Oryzopsis miliacea.—Developed very slowly and produced small, weak tufts which did not reach the flowering stage.

Phalaris tuberosa (and *P.* (?) *arundinacea*).—All samples received under the name of *P. arundinacea* belong probably to *P. tuberosa,* as *P. arundinacea* is a rhizomatous grass of entirely different habit. Six samples were planted in 1953, and they all grew slowly and formed medium-sized, leafy tufts without flowering heads. *P. tuberosa* planted in 1952 produced fairly large leafy tufts with occasional spikes.

Poa pratensis.—Three strains were planted in 1953. They all germinated well but most of the seedlings died in May during a dry spell. The surviving plants developed very slowly and towards the end of the season produced very small, though healthy, tufts. No fertile stems were formed.

GRASSES OF SOUTH AFRICAN ORIGIN

Erharta calycina, Veldt Grass.—Tufted perennial cultivated in South Africa and Australia. In the nursery it formed rather weak tufts and was generally poor.

Eragrotis chloromelas.—Perennial forming broad, dense, vigorous tufts 2–3 ft. in height, with numerous basal leaves. The grass has been tried in Kenya for soil conservation purposes and gave good results. In the nursery it did well and formed vigorous tufts. Seed production was good.

Eragrostis curvula.—Perennial forming broad, strong tufts 1½–3 ft. in height with very numerous narrow basal leaves. The grass is well known in several other countries and in Kenya it has been tried, mainly for soil conservation purposes, and gave good results. It produces usually only a few panicles per tuft, and seed production is only moderately good. Three samples cultivated in the nursery differed slightly in vigour.

Eragrostis lehmanniana.—Tufted perennial. In the nursery it formed rather small tufts and is inferior to *E. chloromelas* and *E. curvula* for soil conservation purposes.

Panicum coloratum var. *makarikariensis,* Makarikari grass.—Perennial, with long prostrate stems rooting from the nodes. The leaves are bluish in colour and harsh but well liked by cattle. Although the grass grew well in the nursery, it did not show any outsanding qualities, and is more suitable for drier areas where the choice of grasses for cultivation is more limited. Six varieties were cultivated in the nursery, and they differed slightly in vigour, habit and seed-setting capacity, which is generally poor in this grass. Makarikari grass is cultivated at Kitale with a view to developing a seeding variety.

Tetrachne dregei, Karroo grass.—Tufted perennial which developed very slowly and formed small, weak tufts with very fine numerous leaves. No flowering heads were produced.

LOCAL KENYA GRASSES

Acrocerus macrum.—Rhizomatous perennial. Six samples of this grass of various origins grew rather well, and produced a moderately leafy, though not vigorous, sward. This grass occurs naturally in swamps and should be tried on wet ground and in seasonal swamps.

Andropogon chrysostachyus.—Tufted perennial which occurs at high altitudes. In the nursery it grew well and produced healthy, medium-sized tufts, each with a few flowering heads. A palatable species which may be of use at high altitudes. Its seeding qualities at Kitale were poor.

Andropogon pratensis.—Semi-prostrate tufted perennial. In the nursery it formed rather weak growth and was stemmy. It may do better at higher altitudes, where it occurs naturally.

Andropogon schinzii.—Tufted perennial which occurs at altitudes between 3,000 and 6,000 ft., mostly on rocky ground. The grass forms erect, leafy tufts with very numerous leaves on the stems, but without basal leaves, and is essentially of the hay type. Of the two varieties cultivated in the nursery one is finer and more suitable for cultivation. In the nursery the grass grew well although it developed slowly in the first part of the season. The leaves were attacked by rust. Seed production was good.

Beckeropsis uniseta.—Tall tufted perennial. Six samples were cultivated in the nursery and they varied considerably in habit, leafiness, hairiness of the leaves, etc. The grass may be of use as fodder or for grazing. Seed production was good.

Bothriochloa insculpta.—Stoloniferous perennial which forms a dense cover, but is rather stemmy. A Kitale variety cultivated in the nursery is more robust and less leafy than the type cultivated at Kitale and Nairobi. *B. insculpta* produces seed very freely, and may be of use in the black cotton soil areas where, unlike other grasses, it can easily be grown from seed.

Bothriochloa radicans.—Tufted perennial of low altitudes. In its natural habitat it forms small, leafy tufts. However, a few varieties cultivated in the nursery produced poorer and more stemmy plants. The grass should be tried under drier conditions at lower altitudes.

Brachiaria dictyoneura.—Tufted perennial with numerous broad basal leaves and tall stems. In the nursery it was inferior to both *Brachiaria brizantha* and *B. soluta.*

Brachiaria nigropedata.—Tufted perennial of medium vigour which occurs naturally in dry areas. In the nursery it produced medium-size, leafy tufts and showed poor seeding qualities.

Brachiaria soluta.—A small or medium-sized tufted perennial. This grass develops quickly and is easy to grow from seed. It is, however, not productive, and is inferior to the best types of *Brachiaria brizantha.*

Cenchrus setigerus.—Tufted perennial similar to *Cenchrus ciliaris,* except that the seeds (spikelets) have only short stout bristles. Although the grass originates from the very dry parts of Kenya, it produced good results in the nursery. It was leafy and remained green long into the dry season. Seed production at Kitale was rather poor as many spikelets did not contain caryopses. This species deserves further study.

Chloris amethystea.—Stoloniferous perennial forming dense, slowly spreading colonies. Seed production is good but at Kitale viable seeds were formed only during the dry season. Although the grass is of low palatability at later stages of growth, there is a possibility of using it for reseeding denuded land in moderately dry areas.

Echinochloa pyramidalis.—Tall and vigorous tufted perennial of which five varieties were cultivated in the nursery. The varieties differed in leafiness and vigour. The grass occurs naturally in swamps and on stream banks and should be tried on moist ground and in seasonal swamps.

Enteropogon macrostachyus. — Perennial with medium-sized tufts. It occurs naturally in semi-desert areas of Kenya. At Kitale the grass was poorer than in its natural habitat; the seed production, however, was good. This species is intended for trial in the reseeding of denuded dry areas.

Eragrostis caespitosa.—Low perennial forming broad, dense and leafy tufts. Although the grass is more suitable for dry areas, it showed promise at Kitale, where, however, the seed production was poorer than in drier areas. The seed is very small and the seedlings develop slowly.

Eragrostis superba.—Tufted perennial of dry areas. Of the two varieties grown at Kitale, one was more leafy.

Eustachys paspaloides.—Low perennial, forming dense, slowly spreading colonies. The grass is intended for trials in dry areas, and in the nursery it gave poor results. It grew very slowly and was attacked by rust.

Hyparrhenia.—Numerous varieties of *Hyparrhenia*, chiefly of *H. hirta* and *H. cymbaria*, were cultivated in the nursery, and in previous years some of them showed good results. No observations were carried out in 1953.

Panicum coloratum.—Tufted perennial. Seven samples were cultivated in the nursery and they showed very little variation. All of them grew fast, and formed dense, leafy swards 2–3 ft. in height and produced numerous panicles. Although this grass grew well on dry land, it would probably do still better on moist ground where it occurs naturally.

Paspalum scrobiculatum.—Low tufted perennial with soft leaves. A few varieties were cultivated and they were fairly uniform. They all grew well, but were not vigorous and only formed thin swards. The seed was produced early in the season, and the plants remained green only for a short time after the beginning of the dry season.

Pennisetum dowsonii.—Stoloniferous perennial which occurs naturally in swamps at high altitudes. In the nursery the grass grew well on dry land and rapidly formed a dense sward about 9 in. in height. This species is closely allied to *P. salifex*, cultivated by D. C. Edwards at Kabete.

Pennisetum polystachyon.—Tufted perennial of which two varieties were cultivated. One variety, from the Coast, produced a large bulk of leaves and remained green long into the dry season. It should be noted that in their natural habitat, at the Coast, the parent plants were more stemmy and less vigorous than their progeny at Kitale.

Setaria holstii.—Tufted perennial resembling *Setaria sphacelata*. A leafy variety of this grass cultivated in the nursery showed some promise.

Setaria longiseta.—Tufted perennial common in the Trans Nzoia. It grew well and produced seed abundantly. The grass is only of medium palatability, but it varies considerably and better varieties can possibly be found.

Sporobolus (?) *fimbriatus*.—Tufted perennial, leafy and of moderate vigour. It produced numerous panicles, but no seed was formed.

Sporobolus helvolus.—Stoloniferous perennial, also forming rather small tufts. The grass occurs naturally on black cotton soil at low altitudes, where it is well grazed by cattle. Of the three varieties cultivated in the nursery, one from Ngong was more leafy and formed a good dense sward.

Sporobolus phyllotrichus. — Rhizomatous perennial forming a low, dense sward.

Stenotaphrum dimidiatum, Pemba grass.—Stoloniferous perennial, which forms a low cover. The grass occurs naturally on the coastal sands. In the nursery it produced only a thin cover and looked unhealthy, having yellowish leaves. Flowering stems were not produced.

Urochloa bulbodes.—Tufted perennial, which produced a leafy sward of medium vigour, and numerous flowering heads. A promising species which deserves further trial.

LAWN GRASSES

Eremochloa ophiuroides.—The grass was originally obtained from Uganda, where it was cultivated as a lawn species. The grass spreads very slowly, and in the nursery after two seasons of growth still had a clumpy appearance. The herbage of *E. ophiuroides* becomes brown early in the dry season, and is hardly suitable as a lawn grass under Kenya conditions.

Brachiaria humidicola.—Quickly spreading stoloniferous perennial, which forms a dense cover of bright green broad leaves about 6 in. in height. Flowering heads are not numerous. The grass is strong and suppresses most of the local weeds. *B. humidicola* is an excellent grass for soil conservation, rough lawns and playing fields, but is unsuitable if a fine lawn is required.

Digitaria swazilandensis, Swazi grass.—Stoloniferous perennial forming a low carpet, if periodically mown. If left uncut, the grass produces dense growth 6–9 in. high with numerous flowering heads which, however, only occasionally produce viable seed, and the grass has to be planted from shoots. The grass is not strong and requires weeding, and it does not stay green long into the dry season. In spite of this it is one of the best lawn grasses for altitudes above 5,000 ft.

Pennisetum clandestinum, Kikuyu grass.—Stoloniferous and rhizomatous perennial. If periodically cut it forms a low carpet with moderately fine leaves. Kikuyu grass requires good soil and at Kitale it does not stay green long in the dry season.

Chrysochlora orientalis. — Low growing spreading perennial, which occurs naturally in Kenya on black cotton soil. *C. orientalis* is being tried as a lawn grass, but it has not produced good results so far as the flowering heads are produced too freely.

Cynodon spp.—A number of lawn grasses of this genus, all of them of South African origin, are cultivated in the nursery, and they belong to the following main types:—

(A) Strong rhizomatous and stoloniferous grasses. They are drought resistant and remain green very long into the dry season, and also resist invasion by weeds. Leaves moderately fine, and if not cut periodically the grass produces dense growth 6–10 in. in height. This type of *Cynodon* should be introduced with care as it may become a weed in gardens or on arable land. The following varieties of our collection belong to this type: "Maadi River", "Elliot", "Skaaplaas", "Quolora Mouth", "Dordrecht" and "Waverley".

(B) This type is less strong with slightly finer leaves, and forms a lower cover and is more suitable for lawns. "Royal Cape" and "Hall's Selection" belong to this type.

(C) Stoloniferous type, very fine and low, with either very shallow rhizomes or none at all. It is only moderately drought resistant, and requires watering during the dry season. "Drake Survey" and "Magennis" belong to this group.

(D) Dhoob Grass. Stoloniferous (no rhizomes) grass, resembling fine forms of our local *Cynodon dactylon.*

The names of the South African varieties of *Cynodon* cultivated in the nursery need to be checked, however, to be sure of their authenticity.

Paspalum notatum.—The original introduction by D. C. Edwards is cultivated as K.50168 and is used at Kitale and in some other parts of Kenya for soil conservation purposes. The grass spreads slowly and forms very dense growth 3–6 in. in height with only occasional flowering heads. The bluish leaves are broad and the sward is strong and requires little weeding. The grass is suitable for planting on banks and steep slopes to prevent soil erosion. It is too coarse for fine lawns.

In 1953 a large collection of varieties of *P. notatum* was obtained from the U.S.A. and Australia. Some varieties in this collection have finer leaves of bluish or bright green colour, and show promise as potential lawn grasses.

LEGUMES

Alysicarpus (?) *Glumaceus** (Kenya).—Perennial sub-erect herb. In the nursery the plants developed slowly and only late in the season did some varieties produce a leafy sward. Other varieties were poor and stemmy. The variety of which seed is multiplied on a large scale represents a mixed population, and valuable forms can possibly be selected. Some work on the selection of leafy and persistent forms was started in 1952 when a number of varieties were selected and planted from splits. Of the six varieties cultivated in the nursery, Nos. 5122 and 51219 were the most promising.

Alysicarpus glumaceus (Kenya).—Annual sub-erect herb. It developed quickly from seed and produced poor stemmy plants, which died towards the end of the season. The plant originates from dry areas at low altitudes.

Alysicarpus longifolius (India).—Produced poor stemmy plants which died at the end of the season.

Alysicarpus rugosus (India).—Erect perennial herb. All four numbers cultivated in the nursery produced poor plants which were weak, low and stemmy.

Alysicarpus vaginalis (India).—It developed small, weak and stemmy plants.

Antopetitia abyssinca (= *Ornithopus coriandrinus*) (Kenya).—Annual erect herb. It germinated well and developed quickly, producing a leafy sward about 1 ft. in height. The flowers appeared early and produced a good crop of seed. The plant is not vigorous and only of short duration, but forms an attractive growth and deserves further trial.

Arachis.—Roots of four perennial species of *Arachis* (*A. diogoi, A. glabrata, A. marginata* and *A. prostrata*) were planted in the nursery, and they all developed low, creeping plants which varied slightly in leafiness and vigour. All species produced rather numerous flowers, but none formed seed.

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* J. Léonard has recently revised Tropical African species of *Alysicarpus*. (*See* Bulletin du Jardin Botanique de l'Etat, Bruxelles, Vol. XXV, Fasc. 1, 1954). He classified as *Alysicarpus rugosus* D.C. subsp. *perennirufus* Léonard our most common species which we believed to be *A. glumaceus*.

Astragalus abyssinicus (Kenya).—Perennial erect herb which grew well in the first season, and produced tall and moderately leafy growth. During the second season the plants were stemmy and soon died. Volunteer seedlings were numerous. The plant is coarse, stemmy and of low palatability.

Astragalus venosus (Kenya).—Perennial sub-erect herb. It resembled *A. abyssinicus*, but produced a lower and denser sward and is more suitable for introduction. The palatability of this species has yet to be tested.

Calapogonium mucunoides (S. America).—Perennial twiner. In the nursery a single plant produced rather good, leafy growth. Although planted in 1951 it never produced flowers.

Centrosema pubescens. (S. America).—Twining perennial herb. In the nursery it formed dense leafy herbage of medium vigour reaching 12–18 in. in height. Flowering and seed production were fairly good. Newly planted in 1953, it germinated well and grew fairly quickly although the flowers appeared only in the dry season. A species deserving further trial.

Clitoria ternatea (Kenya).—Perennial twining herb which occurs naturally at lower altitudes, mostly on seasonally moist plains with heavy black soil. At Kitale during the rainy season the growth was poor and the plants diseased. During the dry season the plant recovered but remained much less vigorous than in its natural environment. Three varieties cultivated in the nursery differed in leafiness, the best variety being from Kiboko (3,000 ft.).

Crotalaria greenwayi (Kenya).—Annual erect herb which occurs naturally at lower altitudes. At Kitale it produced healthy and leafy plants 2–2½ ft. high and seded well. This species may be useful for dry areas, but its palatability has yet to be tested.

Crotalaria incana (Kenya).—Annual erect herb widely spread in Kenya. In the nursery it produced a large bulk of herbage and seeded well. The species may be useful as green manure or for silage.

Crotalaria intermedia (Kenya).—Short-lived, erect perennial herb. The variety cultivated in the nursery produced much-branched vigorous plants of medium leafiness. It flowered early, and a good crop of seed was produced. This legume was cultivated experimentally at Kabete, and the Kabete variety was slightly superior.

Crotalaria lotiformis (Kenya).—Perennial sub-erect herb. In the nursery it developed leafy plants and produced numerous suckers from spreading rhizomes. The plant was weak and low and seems to be unsuitable for general use.

Crotalaria natalitia (Kenya).—Shrubby perennial which occurs naturally at high altitudes. In the nursery it grew well and produced broad, much-branched and leafy plants about 2 ft. high. Later in the season it became diseased and most of the leaves died.

Crotalaria polysperma (Kenya).—Annual erect herb. In the nursery it germinated well, grew fast and produced much-branched plants 1½–2 ft. in height. It was only moderately leafy, with hairy leaves, and seems to be unsuitable for general use.

Crotalaria recta (Kenya).—Tall, erect, short-lived perennial herb. In the nursery it formed very vigorous, leafy plants 6 ft. high with thick, soft stems. The plant deserves further study as it can possibly be used for fodder or green manure.

Desmodium canum (India).—Small, prostrate herb which formed a thin cover 2–4 ft. in height. It developed slowly from seed and began flowering only at the end of the season. The plant is not productive and not promising for ordinary use.

Desmodium distortum (Jamaica). Erect perennial herb. In the nursery it developed slowly, but towards the end of the season produced large leafy plants about 5 ft. in height, well branched in the upper part. It flowered freely and produced numerous seeds. The plant remained green long into the dry season, and is a promising fodder legume.

Desmondium discolor (S. America). Tall perennial herb which produced vigorous erect plants 6–7 ft. in height, with large leaves concentrated mostly in the upper part of the stem. Only a few plants flowered, and produced a small amount of seed.

Desmodium heterophyllum (S. America).—Low, prostrate herb. It grew slowly and formed dense, low and leafy herbage and flowered early. The plant deserves further trial.

Desmodium intortum (Exotic).—Perennial herb with large leaves. It formed fairly dense, vigorous herbage with trailing stems densely covered with tiny hooked hairs and large leaves. Only a few branches flowered and no seed was produced.

Desmodium tortuosum (Tropical Asia).—Erect herb. In the nursery it germinated well, grew fast and produced rather thin foliage. It flowered and seeded early. The plant is stemmy and only of medium quality, but is very easy to grow. It establishes itself well from numerous volunteer seedlings which appear after the first rains.

Three other samples received under the names of *Desmodium adscendens, D. stipulaceum* and *D. purpureum,* which were cultivated in the nursery, were identical with *D. tortuosum.*

Desmodium uncinatum (America).—Semi-prostrate perennial herb. It developed quickly and formed dense herbage 6–9 in. in height with the flowering stems 18 in. high. Seed was produced abundantly and the plant remained green up to the end of the year. An attractive plant well deserving further trial. No. 53384 (from Brazil) represents a more prostrate form which produced low herbage with prostrate stems occasionally rooting from the nodes. It may be a different species.

Dolichos biflorus, Horse Gram (Local and Introduced).—Twining perennial herb. Growth of seedlings is rather slow. The local form with hairless leaves grew fast and developed dense herbage 2 ft. in height. The flowers appeared late and were not numerous. Plants originating from India were very weak and diseased, and died without producing flowers.

Dolichos falcatus (Kenya).—Twining perennial herb. Of six varieties cultivated in the nursery some developed quite attractive herbage with numerous fine stems and numerous leaves. On the ground, without support, some plants produced low trailing herbage and did not last long into the dry season. Others, however, persisted right through the dry season. When climbing it produced more vigorous growth and remained green longer. Nos. 5140 and 5259 showed the best results, being more vigorous than the others. No. 53483 is a fine, early form with less vigour.

Dolichos sp. nr. *D. formosus* (from Kilima Kiu, Kenya).—Twining perennial. The plants found by D. C. Edwards were first cultivated at Kabete. At Kitale it grew quickly and produced leafy, vigorous growth. On the ground, without support, the herbage was 1–1½ ft. high. The plant flowered only when grown on a trellis, and even then only a few flowering racemes were produced. Poor seed production is the main obstacle to the cultivation of this otherwise promising fodder legume. At Kabete, however, and elsewhere near Nairobi, this species flowers and seeds freely.

Dolichos sp. nr. *lablab* (Kenya).—Spreading or twining perennial, indigenous in the Trans Nzoia and Uasin Gishu areas. In the nursery it formed vigorous plants with abundant foliage, flowered profusely and produced seed freely. The development from seed was rather slow at first. A promising perennial for fodder and for ground cover.

Glycine javanica (Kenya).—Twining perennial herb, common and widespread in Kenya. Seventeen varieties cultivated in the nursery showed a wide range of variation in vigour, leafiness, persistence and seed-setting capacity. The following forms produced good results:—

No. 50194, from the Trans Nzoia.—Moderately vigorous and leafy. Good seed producer.

No. 5299, from Arusha, Tanganyika.—Late type, vigorous and leafy. Medium seed production.

No. 52236, from Rongai.—A non-vigorous, prostrate, grazing type, with numerous rather small leaves. Seed production is moderately good.

No. 53486, from Nairobi.—Vigorous, and a good seed producer.

Hedysarum coronarium, Sulla (Mediterranean).—Perennial erect herb. In the nursery the plants were 1–2 ft. in height, moderately leafy and varied in vigour. Seed was produced fairly well. The plant may be of use for grazing or as fodder and deserves further trial. It requires its own specific strain of Rhizobium, and this must be supplied before one can arrive at a final decision.

Indigofera alboglandulosa (Kenya).—Semi-erect, short-lived perennial or annual herb. Moderately leafy, viscous plants which produced dense growth in the nursery. The plants were badly damaged by beetles. The species seems to be unsuitable for cultivation.

Indigofera arrecta (Kenya).—Shrubby perennial. Some varieties produced leafy plants with woody stems 3 ft. in height. The plant may perhaps be used for browsing, but its palatability has yet to be tested.

Indigofera endecaphylla (Kenya).—Prostrate perennial herb. Of the three varieties cultivated in the nursery, No. 52253 produced low, leafy plants of a good grazing type. Seed production was poor and the seed difficult to harvest. The plant was badly eaten by beetles. Experiments in Hawaii showed that this species produced ill effects on grazing animals, and our Kenya forms have yet to be tested for toxicity.

Indigofera suaveolens (Kenya).—Much-branched shrub. In the nursery it produced dense growth 5ft. in height. The plants were stemmy and not suitable for cultivation. The sweet scent of the plant was noticeable at some distance from the plot.

Indigofera subulata (Kenya).— Sub-erect or prostrate perennial herb. In the nursery it was rather stemmy, generally poor, and was badly eaten by beetles. The plant does much better on the fertile red loam of the Nairobi area, where it has been grown and studied on a field scale.

Lathyrus cicera (Europe).—Small annual herb. In the nursery it produced weak, leafy plants with numerous thin stems, and died very soon after seed was produced. Not suitable for local conditions.

Lathyrus (?) *latifolius,* Everlasting Pea (Exotic).—Perennial herb. It grew well and produced vigorous, low plants. Only a few flowers appeared. An attractive plant, but its palatability has yet to be tested.

Lathyrus ochrus (Mediterranean).—Annual herb which produced low, weak plants with numerous prostrate stems. The plants died early after producing seed. Not suitable as a fodder or grazing plant.

Lathyrus sativus (Europe).—Annual herb. In the nursery it reached 18 in. in height, seeded well and died early. A grain legume not suitable for local conditions.

Lespedeza bicolor (East Asia).—Annual semi-prostrate herb which developed quickly and died early after producing numerous seeds. The plant established itself well from volunteer seedlings. It may be of use for cultivation as a catch crop after cereals.

Lotononis bainesii (Tropical Africa).—Creeping perennial herb. It formed a dense carpet 1–3 in. high with numerous flowering stems reaching 4–5 in. The plant grew fast and seeded freely. It is, perhaps, rather low for grazing, but may produce a good cover between grass plants.

Lotus maernsii (Kenya).—Perennial prostrate or sub-erect herb with numerous thin stems. On moist ground it produced dense, leafy herbage about 9 in. in height, flowered profusely and formed numerous seeds. On drier ground thin, less leafy herbage was formed, but seed production was also good. A promising species for the high rainfall areas.

Lotus tigrensis (Kenya).—Perennial herb with numerous semi-prostrate stems. In the nursery it formed dense, leafy herbage. Flowers and seeds were scarce. The plant may be useful as a ley component for the high altitude areas.

Medicago (?) *denticulata* (Mediterranean).—Annual prostrate herb. In the nursery it grew well and produced attractive leafy herbage 4–6 in. in height with numerous small leaves. Seed was produced abundantly. The plant lasted 3–4 months and died after the seed was formed. It has possibilities for pasture purposes. This species has reseeded itself freely for several years now at Kitale, and also withstands grazing well.

Medicago (?) *hirsuta* (Mediterranean).—Annual prostrate herb. Formed small, low plants, inferior to *Medicago denticulata* in vigour and leafiness.

Medicago lupulina (Europe).—Prostrate annual or short-lived perennial. It produced low, fairly dense and leafy growth, and lasted longer than other annual species of *Medicago* but died during the dry season. It flowered and produced some seed. It could perhaps be cultivated in the high altitude areas.

Medicago orbicularis (Mediterranean).—Annual herb. In the nursery it developed quickly from seed and formed fairly vigorous prostrate plants 5–6 in. in height. Flowered and seeded freely.

Melilotus sp.—Several unnamed varieties were cultivated. None of them were particularly good.

Onobrychis sativa, Sainfoin (Europe).—Perennial herb. It germinated well, but grew rather slowly, and towards the end of the season produced small tufts without flowers. The samples planted in 1952 varied considerably in vigour and leafiness and only some of the plants produced seed. The plant is very likely more suitable for cultivation at higher altitudes.

Ornithopus sativus, Serradella (Mediterranean).—Semi-prostrate annual with hairy leaves. In the nursery it grew well and produced a low, leafy sward. The plants established themselves well from volunteer seedlings, but required thorough weeding. It lasted well into the dry season and some plants survived until the next rains. Serradella has been cultivated in Kenya for a few years and in some areas of high altitude has produced good grazing.

Phaseolus lunatus, Lima Bean (Tropics).—Twining herb. In the nursery it germinated well and grew very rapidly, producing leafy, vigorous plants early in the season. The foliage was, however, not abundant. The plants flowered early and produced numerous seeds. Most of the plants behaved as annuals, and died at the end of the season. A fairly vigorous fodder plant.

Psophocarpus lancifolius (Kenya).—Perennial twining herb. Planted in 1952, it produced rather poor stemmy plants which died in 1953.

Pueraria phaseoloides, Tropical Kudzu (S. Asia).—Perennial prostrate or twining herb. Planted in 1951 it was still growing in 1953 and was fairly leafy and moderately vigorous, with the herbage 9–12 in. in height. The plant did not produce flowers.

Rhynchosia elegans (Kenya).—Perennial twining herb. The germination was poor and the seedlings grew slowly and formed rather weak plants which began flowering at the end of the season. The plant developed better at Nairobi, where it produced rhizomes, and formed spreading colonies.

Rhynchosia hagenbeckii (S. America).—Perennial erect herb with hairy leaves. It produced healthy plants 12–18 in. in height, which, however, were stemmy. Not suitable for introduction.

Rhynchosia minima (Kenya).—Twining perennial herb. In the nursery it developed fairly well from seed but formed only scanty herbage. The scent, characteristic of the genus, was very faint in this species. The plant is said to be eaten by animals, but its palatability requires further study.

Rhynchosia sennaarensis (Kenya).—Twining perennial herb. Planted from seed, it produced dense, leafy herbage 12–18 in. in height and flowered profusely. However, seeds were not formed during the rainy season and the plant looked unhealthy, having lost most of its leaves. It recovered during the dry season, produced new leaves and then flowered again, producing seed. At low altitudes (2,000–4,000 ft.) *R. sennaarensis* grows better and produces numerous seeds.

Rhynchosia usambarensis (Kenya).—Twining perennial herb. Planted in 1952 it produced moderately vigorous herbage, flowered late in the season, and formed only a few seeds. At Nairobi it grew better and produced vigorous, leafy plants. Seed formation is poor.

Stizolobium (?) *pruriens* (= *Mucuna* (?) *pruriens*) (Exotic).—Perennial twining herb. In the nursery it lasted two seasons, formed very vigorous plants with large leaves and rather thick stems, and produced numerous seeds. Most of the plants died towards the end of the second year. Of the three varieties under cultivation one produced seed better but was slightly less vigorous and less persistent. A vigorous fodder plant which can possibly be cultivated with maize or Elephant grass, or used as a green manure.

Stylosanthes gracilis (S. America).—Suberect perennial herb. In the nursery it grew slowly and at the end of the season was still not fully developed, although flowers were freely produced. In the second year a dense, moderately leafy sward about 18 in. in height was formed and the plants flowered and seeded well. Three varieties cultivated in the nursery showed slight variation in vigour. A persistent, grazing legume well deserving further study. It is, however, reputed to have a low nutritive value.

Stylosanthes mucronata (Kenya).—Semi-prostrate perennial herb which is slightly viscous. It grew rather slowly and only in the second year developed dense, rather stemmy herbage. The plants flowered freely and numerous seeds were formed; these were, however, difficult to harvest. The plant is said to be eaten by cattle, but this has yet to be confirmed.

Stylosanthes sundarica, "Townsville Lucerne" (S. America).—Perennial prostrate herb. In the nursery it developed quickly, but only formed very low tufts with the foliage 1–2 in. in height, although flowering stems reached 4–6 in. Numerous seeds were produced, but these were difficult to harvest. The plant is scheduled for further trial.

Tephrosia holstii (Kenya).—Perennial erect herb. In the nursery it developed rapidly and formed a very dense, vigorous herbage 4 ft. in height. The plants flowered very late and only a few seeds were produced. It is said to be eaten by cattle, but its palatability requires further study.

Tephrosia subtriflora (Kenya).—Low-growing, semi-prostrate perennial from low altitudes. In the nursery it formed low, moderately leafy growth and flowered and seeded well. This species may be of use for grazing in dry areas.

Teramnus andongensis (Kenya).—Perennial twining herb. It produced rather poor stemmy plants which are said to be of low palatability.

Teramnus labialis (Kenya). Perennial twining herb. In the nursery it germinated satisfactorily, developed slowly, and only in the second season reached its full growth and formed a dense sward about 6 in. in height. The plants have small leaves and very fine stems and do not climb well on a thick trellis, but they climb well up grass stems. The climbing plants in the nursery on the trellis formed a taller mass and flowered and seeded better than those on the ground. This species may do well in a mixture with grasses which, however, should not be too strong. A promising twiner of small grazing type.

Teramnus repens (Kenya).—Twining or trailing perennial. It grew slowly and in the first year formed a thin and patchy growth. A plot planted in 1952 contained poor, unhealthy plants. The species is hardly worth further trial.

Termanus uncinatus (S. America).—Perennial twiner. Planted in 1952, it formed in 1953 leafy and vigorous herbage, climbing well on a trellis. Plenty of seed was produced. This species is of the *Glycine javanica* type and may be of use for grazing or as fodder. The plant certainly deserves further trial.

Trifolium alexandrinum, Berseem (Mediterranean).—Erect annual. In the plot where it established itself from volunteer seedlings it grew fast and produced dense, uniform and leafy herbage about 2 ft. in height. In the plot planted by seed, Berseem developed more slowly and produced poorer, patchy herbage. Earlier germination or better inoculation might be the reason for the better development of the volunteer plants. Berseem forms an attractive herbage, seeds well, and is one of the best annual legumes cultivated in the nursery. Of a few varieties cultivated in the nursery in 1952, Portuguese Berseem gave the best results, and this variety was planted in 1953.

Trifolium burchellianum (Kenya).—Perennial herb. Of this species only a few plants were grown in the nursery. They were healthy and fairly vigorous, but flowered very sparsely and did not produce seed.

Trifolium burchellianum var. *johnstonii* was of a more creeping habit, lower and less vigorous. It did not produce seed either.

T. burchellianum occurs naturally at high altitudes (8,000 to 10,000 ft.) where it is fairly vigorous, and undoubtedly deserves further study.

Trifolium cheranganiense (Kenya).—Perennial prostrate herb. Planted in 1952, it produced in the second season a low and leafy sward, and also flowered. A plot planted in 1953 developed slowly and did not cover the ground to any appreciable extent. The species may do better at higher altitudes, and deserves further trial.

Trifolium cryptopodium (Kenya).—Creeping perennial of high altitudes. Planted from roots it produced numerous creeping stems and flowered profusely during the rainy season. The plant forms only a very low cover and therefore can hardly be used for grazing. However, at high altitudes it may develop a good cover between the tufts of grasses.

Trifolium hybridum, Alsike Clover (Europe).—Perennial herb. Of the three samples cultivated in the nursery, the best results were shown by a Canadian variety which produced broad plants 6–12 in. in height with a few flowering heads. This species, and particularly the Canadian variety, survived the dry season better than other European clovers and deserves a further trial, although the area of its potential cultivation is more likely to be at higher altitudes.

Trifolium pratense, Red Clover (Europe).—Perennial herb. Planted in 1953, it developed slowly and formed rather weak plants which did not flower. Of another strain planted in 1952, only a few plants survived the dry season. The plants were healthy and produced a few flowers, but lacked vigour. Both varieties cultivated in the nursery belonged to the late-flowering type. Red clover is unsuitable for Kitale conditions and should be tried at higher altitudes.

Trifolium repens, White Clover (Europe).—Perennial prostrate herb. An ordinary variey produced weak plants which formed only a poor cover. Italian Ladino Clover gave better results and developed rather vigorous plants which, however, did not produce flowers.

Trifolium rueppellianum (= *T. subrotundum*) (Kenya).—Sub-erect annual. It developed quickly, flowered profusely and seeded well. A few samples cultivated in the nursery differed in vigour and leafiness, and Nos. 51302 and 53498 were the best ones. Although this species is only of medium vigour it forms and attractive cover, seeds well, and is one of the best local annual legumes, well deserving of further study.

Trifolium semipilosum, Kenya White Clover (Kenya).—Prostrate perennial herb.

Var. *glabrescens* resembles the European white clover. It forms a dense low carpet and grows well during the rainy season. During the dry season the plants are dormant. This variety is widely spread in Kenya at altitudes of 6,500 ft. and upwards. Sixteen strains cultivated in the nursery differed in vigour and three of them were definitely more vigorous than the others. They formed herbage 5–8 in. in height as compared with only 2–3 in. in the poorer types. This variety is under extensive trial.

Var. *kilimanjaricum* differs in having narrow leaflets and more prostrate and low growth. In the nursery it produced very low, poor cover. This variety may do better at high altitudes.

Trifolium simense (Kenya).—Perennial erect or sub-erect herb. In the nursery only a few seeds germinated and they produced small, weak and stemmy plants.

Trifolium steudneri (Kenya).—Erect or sub-erect annual. It germinated well, grew fairly quickly and produced dense, rather stemmy herbage. *T. steudneri* is a good seeder and easily establishes itself from seed. It belongs to the same type as *T. rueppellianum*, but is more stemmy and, therefore, less valuable.

Trifolium subterraneum (Mediterranean).—Prostrate annual. A few varieties of this well known species were cultivated. They all produced low and patchy, non-vigorous cover, and no strain showed any encouraging results.

Trifolium tembense (Kenya).—Erect or sub-erect annual. It grew fast and formed a dense, moderately leafy herbage 9–18 in. in height. The plant seeded well and established itself easily from seed. Out of four varieties cultivated in the nursery, only one showed encouraging results.

Vigna gracilis (Kenya).—Prostrate perennial. In the plots on dry ground it germinated satisfactorily, grew rather slowly and developed only very patchy and low cover as many plants died during the season. In a plot on wet ground it formed a dense and leafy cover. The plant seems to be suitable only for moist situations and for the areas with high rainfall, as at Kitale. During the dry season most of the plants dry out.

Vigna heterophylla (Kenya).—Annual twining herb. It grew fast and developed fairly vigorous plants. Plenty of seed was produced. One variety (No. 531026) was outstanding in leafiness, while the others were rather stemmy.

Vigna membranacea (Kenya).—Prostrate perennial herb. It germinated well and produced low, thin, leafy herbage.

Vigna oblongifolia (Kenya).—Annual twining herb. It germinated well and grew quickly, but produced plants which were neither vigorous nor leafy. Not worth further trial.

A closely allied species of *Vigna* was also cultivated. It differs in having finer stems and smaller leaves and flowers. It produced better herbage, which, however, lacked vigour. The plant may do better on moist ground.

Vigna vexillata (Kenya).—Perennial twining herb. It produced rather vigorous but mostly stemmy plants which flowered well and formed seeds. Four strains cultivated in the nursery varied slightly in leafiness.

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A SYSTEM OF CULTIVATION IN THE MBEYA DISTRICT OF TANGANYIKA

By J. K. Robertson and C. W. Rombulow-Pearse, Department of Agriculture, Tanganyika

In the *East African Agricultural Journal* for October, 1950, a description is given of a system of mound cultivation practised in the Ufipa district of Tanganyika. Many who have seen this system of cultivation have made the obvious suggestion that instead of throwing the upturned turves into mounds when breaking up the land from bush or grass-fallow, the upturned turves be made into continuous banks laid out on the contour, but any such suggestions have made no impression whatsoever on the conservative-minded Wafipa. It is refreshing, therefore, to find such a system already in use in certain parts of Mbeya district in Tanganyika.

The main cereal crops in Mbeya district are finger millet (*Eleusine*) and maize, the principal legumes being bush beans (*Phaseolus*) and field peas (*Pisum*); root crops grown are sweet potatoes and cassava. The cereals are planted from the beginning of the rains in November/December until January; then a first weeding of these crops is done and any beans or cassava interplanted in the maize. A start is then made to break up new land for the first time and bring into cultivation land which has been resting under tumble-down fallow.

Much of this bush or fallow-land at this time is covered with a dense growth of *Hyparrhenia* which is cut and laid in rows on the contour approximately 5 ft. apart (Fig. 1). The rows of grass are then covered with inverted turf and any loose soil piled on top, care being taken to avoid piling any great quantity of subsoil on top of the bank. The completed banks are roughly 1 to 1½ ft. high (Fig. 2). Construction of these banks should cease with the end of the rains in May so that the buried vegetation can remain sufficiently damp to rot down before the next rains, and also because labour is required at this time for harvest.

The soils where this system of bank cultivation is practised are not particularly suitable for the growing of cereal crops when first broken up; cultivators have already learned by bitter experience that the yield of maize on such land is low and they generally plant legumes (bush beans or peas) as a first crop on these banks. The banks are broken down at the beginning of the next rains (November) when the *Hyparrhenia* and inverted turf have rotted down. Eleusine is then grown on the flat (with a few maize plants inter-sown) and this is followed for the next season by a further crop of eleusine (with maize interplanted), by which time the growth of weeds in the eleusine is so dense that the weeding of the crop becomes too laborious. The land is then ridged and a succession of maize crops grown until the yields are no longer economic. Cassava is then interplanted in the last crop of maize grown on ridges and after the cassava is dug up two years later the land reverts to tumble-down fallow. The rotation, therefore, becomes:—

Season	
1st:	Banks made in February and beans or peas sown.
2nd–3rd:	Banks broken down in October/November and eleusine grown on flat. Maize interplanted.
4th–5th:	Banks re-made and planted to maize. Cassava interplanted in final crop of maize.
6th–7th:	Cassava.
8th–11th:	Tumble-down fallow with *Hyparrhenia* predominating.

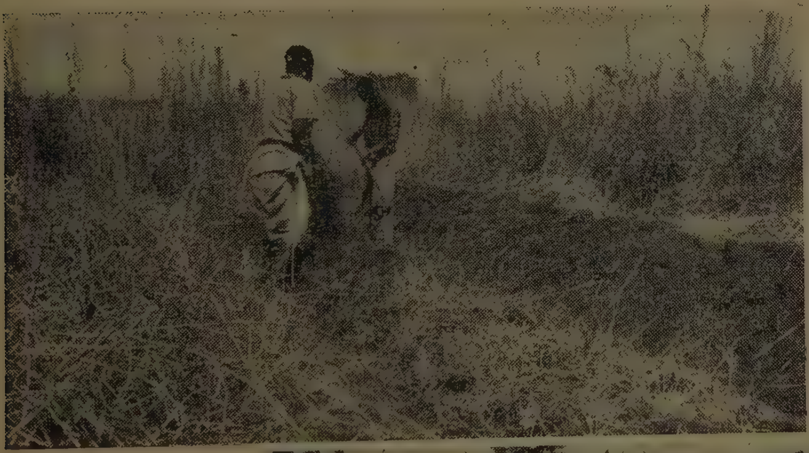
The rotation, of course, centres on the growing of eleusine, the number of eleusine crops grown in a single rotation being determined largely by the amount of weed growth. Eleusine is normally broadcast instead of being sown in rows and the weeding of the subsequent crop can be laborious in the extreme. Where the original growth of *Hyparrhenia* is tall and dense this effectively smothers other species and the land is virtually weed-free until other weeds assert themselves. The system is, therefore, most successful in areas where *Hyparrhenia* is the dominant genus in the indigenous vegetation or in the subsequent tumble-down fallow.

Objections to this system of bank cultivation are that it involves much hard manual labour in a short period and that it is not suitable where ox-ploughing or mechanical cultivation is the rule. The complaint regarding the hard manual labour is very apt. Where ox-ploughing is the rule it is possible to make quite fair banks by ploughing a series of ridges of 3–4 double furrows and already one local African has adopted this method.

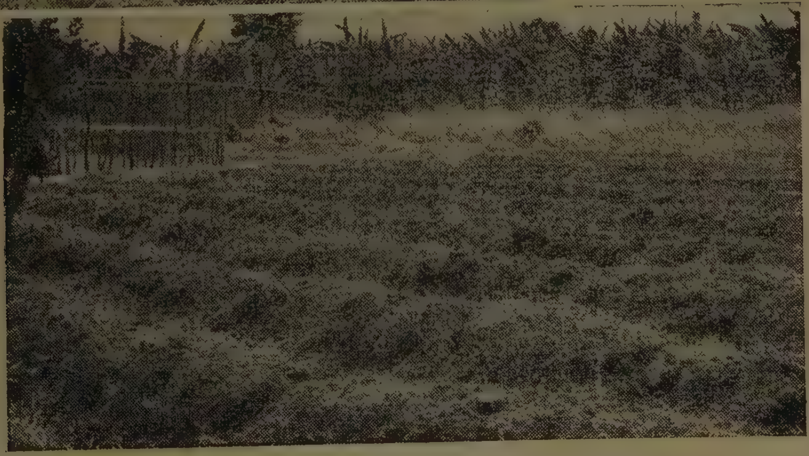
A local modification of the system is seen where broader banks are made and cassava interplanted in the first crop of maize. The soil on the upper side of the bank is pulled down into the furrow and eleusine planted. This modification is particularly valuable from the point of view of soil conservation.

The main advantage of this system of bank cultivation (known in Kiswahili as *kuvundika matuta*) is that it involves no burning of grass or turf and is a welcome change from the "chitemene" system whereby bushland is clear-felled, the superficial vegetation of trees, shrubs and grass burnt off and eleusine sown in the ashes. One obvious weakness in the system is when the original banks are levelled out and eleusine grown on the flat since losses by soil wash could be high, but this can be greatly reduced if, say, every sixth bank is left intact.

The surprising thing is that this system has been in operation for a comparatively short time (possibly 20 years) and cannot, therefore, be described as an indigenous system as, say, the Matengo pit system of Songea district. That its value is appreciated is proved by the increasing extent to which this method is used.



Left:
Fig. 1—Covering cut grass with inverted turf.



Right:
Fig. 2—Completed banks.

EARTH-EATING AND THE MINERAL NEEDS OF LIVESTOCK*

By M. H. French, Joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.

The feeding of "salts" to domesticated animals can be traced back to the time of Plutarch, and both Virgil and Pliny recommended salt for milk production. Although the value of salt has been known for centuries, it did not become common practice to feed it to domestic animals so long as they remained unimproved "starved, todbellied runts, neither fit for the dairy nor the yoke".

Following the enclosure of land in Britain, livestock improvement became possible, and it is interesting to note the numerous references to the feeding of salt in agricultural literature, between 1750–1850, when important advances were being made in the size and productivity of cattle. These livestock improvements created a demand for more knowledge of animal requirements and of the nutritive values of their feeding-stuffs. In response to this stimulus, de Saussure (1804) demonstrated that the ash constituents of plants varied with the soil and the stage of growth, while Sprehgel (1832) suggested that minerals in the ash of fodders were of importance in animal nutrition and, shortly afterwards, Boussingault proved that this was so. About the same time, it was reported that indigenous cattle in certain areas of South America regularly drank saline waters and that ill-health developed when they were prevented access to such waters or to salt deposits.

Turning to the African continent, it is curious that the first references to mineral requirements of livestock was not concerned with salt but with the chewing of bones. Unfortunately, neither the significance of Le Vaillant's Namaqualand observations in 1780, nor the importance of other nineteenth century reports in southern Africa, were appreciated. Like Don Azaro's 1838 report of bone chewing by Paraguayan cattle, the causes of African osteophagia were unravelled only some 35 years ago by South African workers.

As white explorers and colonizers penetrated more deeply into the African continent, they encountered more and more examples of animal husbandry reminiscent of biblical times and practised in the nomadic tradition of Abraham. It became clear that the licking or eating of certain patches of soil by wild and domesticated animals, at regular intervals or whenever the animals had access to these patches, had been occurring for centuries. Earth-eating was, in fact, regarded by herdsmen, in many parts of Africa, as a perfectly natural habit essential for the maintenance and fertility of their stock. So strong was this belief that, even to-day, if no edible-earths are available in the normal grazings, tradition has made it customary to trek animals at regular intervals to patches of soil which are relished or to bring such soils to the animals.

Deliberate earth-eating by cattle in Europe is so rare that the immigrant Europeans sought for some physiological basis on which to explain it, and in the early years of this century it was generally accepted that earth-eating was the satisfying of a craving for something missing from the diet, or the expression of an unsatisfied craving caused by ill-health or serious malnutrition. Thus Meredith (in 1873) reported that earth-eating was "not necessarily a sign that the animals are ill-provided; they do not often do it. Usually an elephant eats a large quantity of earth for a day or two at stated intervals but, if he takes to earth-eating day after day, although it be only a little at a time, it is a tolerably sure sign of the animal being in a bad way".

Early immigrant Europeans, remembering the age-old custom of feeding salt to cattle in their native lands, the licking of perspiration-soaked clothing of climbers by mountain sheep, and noting that many edible-earths occurred on the edges of dried up swamps and contained whitish particles with a salty taste, assumed the deposits were eaten for their salt contents and referred to them as salt-licks. Unfortunately, many other patches of soil were eaten which differed hardly at all from the surrounding soils and did not have a salty taste, while others resembled talc-like clays.

The first edible-earths to be examined chemically in East Africa came from the Lumbwa caves. Hobley, in 1919, reported it was suited to cattle and eaten with avidity from long wooden troughs, although it was not of a saline nature. He stated that "the rock is very attractive to domestic animals, for when we approached these troughs my mule, who had never been to Lumbwa before, whinnied and rushed to one of the troughs and commenced to munch the powdered rock without hesitation". Subsequent analyses showed the lick to consist largely of aluminium silicate, with 5 per cent each of sodium and iron oxides and 3 per cent of lime, and the reason for its consumption could not be explained. During the next 10 years, 25 samples of edible-earths were analysed from Kenya and none contained sufficient sodium chloride to suggest they were eaten to satisfy a craving for common salt. Only five of the samples contained 5 per cent of soda in the form of carbonates, bicarbonates, sulphates, or silicates, and the reason why they were eaten remains a mystery because the lime and phosphate contents were also negligible.

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* Text of a paper read at the Annual Meeting of the Kenya Science Teachers' Association, 29th April, 1954.

The next series of licks to be analysed came from the Arusha district, and although they contained little salt they were composed of up to 57 per cent sodium bicarbonate and up to 34 per cent of sodium carbonate. In this case it might be thought that the deposits were eaten for their sodium contents, but analysis of the waters in the areas indicated that they, too, were rich in carbonates and bicarbonates of soda and that the intake of sodium from the licks represented only a fraction of that obtained from the water which the animals drank. Again no reason could be found for the eating of the licks.

Sixteen other licks were analysed in Tanganyika, and were found to vary from almost water-insoluble soils to rich salt-cakes. It must be recognized, however, that all analyses of East African edible-earths were made before the importance of the "trace" elements was discovered and, although there is as yet no proof, it is possible that the earths were eaten for the trace elements they contained.

Recent work has shown that, in some areas of East Africa, the supply of one or more of the elements phosphorus, sodium, chlorine, copper and cobalt may be dangerously near the borderline of sufficiency, and that the first two can be insufficient for high production. In other areas there is no suggestion of deficient mineral supplies and yet earth-eating is a normal husbandry feature. What then is the cause of earth-eating and what psychological or behaviour complexes induce stock both to start eating earth or chewing abnormal materials and then to continue with these habits?

No explanation fits all the facts. The simplest and most common explanation is to postulate that the animals are in need of some nutrient, not available in sufficient quantities in their diet, and that they eat the abnormal substances to correct these shortages. One can think of many instances where this hypothesis appears to hold good, e.g. the chewing of bones by cattle on phosphorus deficient herbage, the licking of whitewashed walls by cows and pigs to secure badly needed lime, and the consumption of salt by hard-worked horses and camels to replace losses in perspiration. This hypothesis could also be extended to cover such depraved appetites as eating of dung by swine, the drinking of urine by cattle, and the eating of wood-ashes by sheep and camels. The craving for a missing nutrient could be used to explain the chewing of wood, the gnawing of horns, the eating of wool, string, hide ropes and miscellaneous rubbish, if one assumes they are the experimental probings to meet an instinctive craving. The persistence of such depraved appetites is not easy to explain, in any case, the hypothesis breaks down when applied to the depraved appetites which follow the consumption of an excess of certain elements such as selenium. There are many supporters for the suggestion that the searching out and consumption of these abnormal substances is a result of nervous reactions to, or irritations arising from, sub-clinical and pathological manifestations of deficiencies or diseases. On the other hand, boredom, curiosity or devilment are probably behind the chewing of washing, paper, soap and cigarette ends by goats.

Much emphasis has been laid on the idea that the consumption of abnormal substances is an attempt by animals to correct deficiencies in their diets. To quote one example: "Is then the predilection for bones something instinctive, or is it a piece of acquired knowledge obtained by sound scientific method of trial and error—knowledge acquired most easily, perhaps, by the wiser ruminant chewing the cud of reflection after satisfying an obscure hunger on the skeletal debris of a departed brother and then passing on the precept as herd experience?".

It is difficult to believe that animals seek out supplements to correct specific dietary deficiencies, because man is apparently unable to do so, and there is no reason why animals should possess superior powers in this respect. No experiments have yet proved that animals instinctively know when dietary deficiency or excess is likely to lead to ill-health and consequently search for specific remedies. It is true that caged experimental animals, offered a choice between adequate and deficient synthetic diets, may choose the former, but to argue that this discrimination applies under field conditions is to stretch matters rather unduly. Cattle on deficient herbage will chew bones but leave other phosphatic supplements, even bone meal, untouched. Calves which have never been out with the adult herd, but which have been reared on the same phosphorus deficient herbage, do not exhibit a predilection for bone chewing. In the same way, only a portion of a sheep flock, suffering from bush-sickness, will learn to consume curative cobalt-containing licks.

If discriminative powers were possessed by domestic animals, it is difficult to understand why they sometimes consume an excess of salt, copper, molybdenum, selenium and fluorine. This failure of the selective instinct is particularly apparent when one moves a herd a cattle from its known grazing grounds to another and different environment and introduces the problem of herdsman influence. Cases are known where locally engaged, inexperienced herdsmen have taken cattle along a well-used stock-route and have lost large numbers from plant poisoning, whereas experienced drovers, using the same route, have not been known to lose an animal from this cause.

Macro-chemical analyses have shown that certain elements are present in the soil, the herbage and the bodies of animals grazing this herbage. More delicate spectrographic methods have added a number of elements which are present in such small amounts that, in the older methods of analysis, it was possible to record their existence only as "a trace". It has been proved that certain trace elements are essential to health and production, even though they are present in such minute quantities. Sixty elements have been identified in plants, but only a few have proved essential for livestock growth, health and normal reproduction. In practice, the ones most likely to be in deficient supply are calcium, phosphorus, iodine, iron, copper, and cobalt, while magnesium, potassium, sodium, chlorine, sulphur, manganese, and zinc are also essential elements but are normally available in sufficient quantities to meet animal needs.

According to the conditions of feeding and the type of livestock, a deficiency of any essential element may become a limiting nutritional factor. Experience has shown that it is not necessarily those elements required in the greatest amounts which are most likely to be inadequate in the food, and deficiencies and pathological conditions can occur when the minute requirements for trace elements are not adequately supplied. It is not the total quantity of an element which is important, but the difference between the animal's requirements and the quantities available from its food.

Much has been written of the carbon-nitrogen cycles in the soil, plants and animals, but much less is taught regarding mineral needs. About 100 years ago, Lawes and Gilbert showed that the animal body contained approximately 5 per cent mineral matter, and it is now realized that this small amount plays a disproportionate share in metabolism.

Although mineral analyses of soils, herbage and animals commenced during the first half of the 19th century, and much data accumulated during the second half, it was not until this century that the mode of action of the various minerals was elucidated. In fact, in the early years of this century, rations were judged by their ability to provide proteins and energy, and it was not until the importance of the accessory food factors, or vitamins, had been realized, and evidence obtained of the spectacular recoveries which could be produced by feeding vitamins to deficient animals, that biochemists received the necessary stimulus to search for other deficiency diseases. This work quickly demonstrated that mineral deficiencies in the herbage could impose a heavy drain on the economics of livestock production, and that specific mineral supplements could cure serious pathological conditions. These spectacular recoveries from serious deficiency diseases focused attention on the mineral needs of livestock, and led to the realization that sub-clinical deficiences exist over wide areas and can have an even greater economic significance than where gross deficiency is causing pathological symptoms of such a severity as to attract attention.

The literature, in the earlier part of the century, contained numerous references to the morbidity and often fatal nature of such conditions as bush-sickness, pining, swayback, scours, stiff-sickness, licking disease, big-neck, grass staggers, blind staggers, wobbles, falling disease, and sudden death. Similarly, one read of coast disease, Morton Mains disease, Polders disease, Mairo dopiness or Nakuruitis. This by no means exhaustive list of local names indicates the symptoms and the farming areas affected, and suggests that an unhealthy condition can be recognized by experience as a frequent hazard in stock-raising ventures. Stockowners in East Africa also recognize the association of nutritional diseases with certain districts, e.g. "Ol Moru" and "Narurasha" and there are numerous experiments showing the need for, and the economic and physiological responses to, mineral supplements.

PHOSPHORUS

Phosphorus occurs in the body as inorganic salts or esters of ortho-phosphoric acid. It is present in the phosphatides involved in the trans-location of fatty acids in the body and across cell membranes. It occurs in phospho-proteins and phospho-lipoids and plays an important rôle, in the form of hexophosphates, in carbohydrate metabolism.

The elements calcium and phosphorus are usually considered together in animal metabolism because of their intimate association in bones and teeth. Bone growth involves both these elements and a deficiency of either interferes with the assimilation and retention of the other. Over 99 per cent of the body calcium and 80–85 per cent of body phosphorus are located in the skeleton. Lack of either or both elements in the rations of young and growing animals interrupts their deposition in developing bones, and will in time cause the bones to be so weak that they cannot support the body without becoming distorted.

A serious unbalance in the calcium to phosphorus ratio will also lead to bone abnormalities, even when these elements are not deficient in absolute amounts. Generally, so long as the ratio of calcium to phosphorus varies between 1:2 and 2:1 the body can utilize both elements efficiently, but outside this range excess of one element reduces the utilization of the other. Bone lesions, which develop as a result of an absolute deficiency of either of these elements, or of abnormalities in the ratios in which they are fed, can be cured by the provision of the deficient element or the correction of the abnormal ratio, provided the bone lesions have not progressed too far. They can be prevented completely by proper dietary intakes. On the other hand, if the bone lesions have reached an advanced stage they are permanent, and the bones are then fragile and easily broken.

The quantity of these elements in the blood and other fluids of the body is thus in equilibrium between the intake from the food and the losses due to bone formation, lactation, egg production, or excretion. When food supplies are adequate, bones can be formed and any surplus of the elements is excreted in the bowel. When food supplies are inadequate, the fluids bathing the bones take up minerals, and the skeletal structures, therefore, serve as reserves to meet temporary or sudden demands by the body.

Not only must both elements be present in adequate amounts and in the correct proportions, but for normal bone development an adequate supply of vitamin D must also be available. Deficiency of vitamin D increases the rate of excretion of these elements, while an excess reduces this rate. Deficiency of vitamin D reduces the net absorption and may result in a net excretion, so that bone reserves are depleted and rickets or aphosphorosis results. Excess of vitamin D decreases the rate of excretion to the point where not only are the skeletal tissues fully calcified but calcium and phosphorus are also deposited in the soft tissues such as the heart, kidney, and intestines. Failure of phosphorus and calcium metabolism may occur at any age, whenever nutritional supplies fail to meet functional needs. In both young and adult animals deficient intake leads to a depletion of the skeletal deposits and the bones become weakened, so that lameness, bone deformities, and fractures result. Also, unfortunately, when bone reserves are mobilized to meet a deficiency of either calcium or phosphorus, both elements are withdrawn, and the unwanted element is excreted unused.

Phosphorus Deficiency.—Lack of phosphorus is widespread and may affect all domestic animals, but cattle are more susceptible than sheep or horses. Deficiency causes retarded growth, low blood inorganic phosphorus contents, impaired utilization of nutrients, abnormal bone development, fragile and easily fractured bones, lameness, stiffness, reduced reproduction rates and milk yields, loss of appetite, emaciation, and unthriftiness. In advanced cases it causes a depraved appetite and bone chewing, and if not corrected it may lead to collapse and death. Lack of phosphorus, therefore, not only has serious economic effects on livestock industries, but, because of its less obvious effects, such as reduction of appetite and food consumption, can lead to even greater economic losses.

Deficiency of phosphorus in East African pastures has been reported from many areas, and instances of bone-chewing have also been recorded. Low inorganic blood phosphorus has been observed in growing and lactating animals, and in these cases it is fairly certain that production efficiency has been impaired, growth rate slowed down, and milk yields reduced. Over a wide area of East Africa the phosphorus in the grazings, although sufficient to maintain slow maturing and low producing indigenous stock, is inadequate for high-producing cattle, irrespective of whether they are of imported or indigenous breeds. Phosphorus supplements are probably, after salt, the most urgently and generally needed supplements for ruminants in East Africa. No records exist of local cattle chewing bones to which carcass debris still adheres, and it is unlikely, therefore, that the lack of phosphorus is so serious as to cause gross pathological symptoms of deficiency. Only seriously phosphorus deficient animals will chew bones to which carcass debris is attached, and if the debris is contaminated with bovine botulism, lamsiekte and death result. In fact, in gross deficiency the craving is so great that the animals will risk a quicker and more certain death from bovine botulism in an attempt to meet their phosphate hunger.

The simplest method of correcting deficiencies of phosphorus is by feeding leguminous fodders and hays or giving the animals access to bone meal or licks containing phosphorus. European farmers have found that these methods pay, while African farmers in the more developed areas are rapidly learning that such supplements are economical.

CALCIUM

Calcium occupies a peculiar position among inorganic metobolites. It is an important element in the rigid framework of bony tissues, where it occurs in the proportion of two parts of tricalcic phosphate to one of calcium carbonate. Under certain conditions calcium salts may be precipitated in the soft tissues. Calcium exerts a marked regulating action on the motor systems, and its presence is essential for the clotting of blood. The solubility product of calcium salts is an important factor in these changes and in controlling the absorption and excretion from the alimentary tract. Absorption, in particular, is influenced by the concentrations of phosphates, sulphates and saponified compounds in the gut.

Cell membranes are impervious to calcium ions but the calcium contents of body fluids, though small, are relatively stable. Calcium, in physiological concentrations, is precipitated from solutions containing phosphates and bicarbonates if the two latter are present in the same proportions as in the blood. Obviously, therefore, the calcium in the body fluids is present in concentrations higher than can be accounted for by the normal laws of solubility, and approximately a third to a half of the calcium in blood serum is loosely combined with proteins in an unionisable and indiffusible form. It has not yet been decided to what extent the diffusible and ionisable portion is the effective factor in controlling tetanic convulsion.

Pathological symptoms of calcium deficiency are probably never encountered in ruminants in East Africa. On the other hand, the high rate of calcium excretion in milk by high-yielding cows is a drain on the skeletal reserves, and calcium supplements should always be fed to dairy cattle. Pigs, because of their intensive management and their large consumption of cereals and cereal by-products, may suffer from shortage of calcium and should be given supplements containing lime. Egg-laying also imposes a severe drain of calcium, and hens should have access to additional calcium-containing foods which are essential for economic egg production.

Horses sometimes suffer from calcium deficiency when fed large quantities of cereals and brans, and among the first symptoms are stiffness, lameness, stumbling, and a disinclination to move. In more advanced conditions the bones become porotic, soft, and swollen. The swelling is particularly noticeable in the head, and Miller's disease is sometimes referred to as "Big Head". As the term "Miller's disease" suggests, these conditions occur when horses receive large quantities of bran without compensating amounts of lime.

A convenient way of supplying lime is to mix ordinary builders' lime or whitewash with the concentrate portion of the ration, or to feed it as a lick after mixing it with salt.

SODIUM AND CHLORINE

It is difficult to discuss the sodium requirements of stock without reference to chlorine, because the two elements are closely associated with one another, and with potassium, in the osmotic relationships between body fluids. Sodium and chlorine are found chiefly in the body fluids and soft tissues, and animals have no means of storing large quantities. Amounts taken in excess of requirements are quickly eliminated by the kidneys, and excessive intakes may lead to poisoning in certain cases and œdematous conditions in others. When the intake of these elements is low, the body attempts to conserve them by reducing their rate of excretion. When, as with a high-yielding cow, other body secretions are drawing on the supply of these elements, a point can be reached when the kidneys can no longer reduce excretion to a level which will prevent body losses, and the only way the animal can conserve these elements is to reduce its secretion of milk.

The effects of salt deficiency in milking cows were investigated early in this century, and it was found that cows deprived of salt for two or three weeks developed a craving for it, but that a longer period, in some cases up to a year, was necessary before health was affected. Eventually, however, salt deficiency caused loss of appetite and unthriftiness, reduced milk yield, and loss in weight.

Experiments have demonstrated the need for feeding salt to maintain optimum growth in every class of livestock, to obtain full egg production and maintain the necessary appetite for economical rates of fattening. Generally speaking, salt should be fed to all classes of livestock, at a rate equal to 0.5 per cent of the dry matter in the total ration.

Quite apart from its nutritional value, salt acts as a condiment for stimulating appetite and for rendering other foods more palatable. Because of this property it is a normal constituent of all salt licks fed to supply other mineral needs. In hot climates, particularly for animals which perspire, salt is of even greater importance than in temperate regions. In East Africa most European farmers feed salt to high-producing stock and gross symptoms of its deficiency are not encountered. This does not mean, however, that the optimum amounts of salt are being fed, and there are references to pathological conditions resulting from salt shortages in camels. It has been shown that salt is beneficial in preventing "gudan", an arthritis of Somaliland camels. Salt will also prevent the camel disease "dalhan", characterized by cutaneous necrosis and painful local swellings which can develop into open enlarging skin sores. Such salt-deficient animals become lethargic, their milk yields are reduced, their coats are dull and dry, and any accidental wounds or sores heal with difficulty.

Certain grazings in East Africa, particularly in the dry season, are low in sodium and chlorine, while green grass may also contain little sodium, even in the wet season. Salt is, in fact, the most needed nutrient for livestock throughout East Africa.

POTASSIUM

Potassium is widely distributed in plant tissues, and, though essential for animals, forms but a small proportion of their body. Potassium is the predominant base in the body cells, whereas sodium is more abundant in the plasma and body fluids. There appears to be an optimum concentration of each individual base which the organism strives to maintain in each fluid and tissue and, under normal conditions, succeeds in doing so within narrow limits. If the cell membranes were permeable to bases, the distribution of sodium and potassium would, according to Donnan's law of equilibrium, be the same in cell fluid as in the extra-cellular plasmas. The observed differences indicate that normally the membranes are impermeable to these cations. In fact, one of the most stabilized body systems is the total electrolyte concentration and the relative proportions of the cations, sodium, potassium, calcium and magnesium. In contradistinction, individual anions are subject to gross variations within the body and the variations apply chiefly to the bicarbonate, chloride, phosphate and organic acid ions.

MAGNESIUM

The rôle of magnesium in animal metabolism is imperfectly understood, although the element is widely distributed in the body and particularly in the bones. Its action appears to be closely integrated with that of calcium and phosphorus, and disturbances in the metabolism of the latter frequently complicate studies on magnesium. Experimentally, it can be shown that low intakes lead to low values in the blood and to convulsions. Low values are sometimes recorded in grass-tetany, when stall-fed cattle are turned out to lush spring grass, and the symptoms can be relieved by either magnesium or calcium therapy. Similarly, the tetanous symptoms and low blood magnesium values which develop in calves reared too long on milk, without other foods, can be relieved by magnesium therapy. Excessive intakes have been reported as interfering with bone calcification, but later work does not confirm these findings when the diet contains adequate supplies of calcium and phosphorus. This indicates the unsatisfactory nature of our knowledge of magnesium requirements by stock but, fortunately, it is unlikely that normal rations in East Africa will lead to deficient intakes.

SULPHUR

The body content of sulphur is only 0.15 per cent, present chiefly in organic combination, although animals can utilize inorganic sulphates for synthesizing their complex organic compounds. Although essential for health and production, and for the formation of the aminoacids cystine and methionine, sulphur is normally present in adequate amounts. Current experiments in Uganda are being watched with great interest because the preliminary data suggest that sulphates have a beneficial effect on cattle on the shores of Lake Victoria, while other work has indicated that fish growth in the lake is retarded by shortage of sulphur.

ZINC

Zinc is found in all animal tissues and foodstuffs. It is essential for normal metabolism and is apparently a constituent of insulin. Owing to the adequacy of the supplies in plants, there is little risk of deficiency occurring in normal livestock.

MANGANESE

Manganese is found chiefly in the liver, pancreas and suprarenals, and it has been suggested that it is concerned in the development of pituitary hormones and the regulation of the sex glands. There is no evidence of manganese deficiency in grazing animals in East Africa, but deficiency can lead to male sterility, interference with lactation, and the loss of the normal maternal instinct. In chickens, deficiency can result in perosis, or slipped tendon, and a bone condition in which the normal manganese content is reduced to about a third of its normal value. The provision of small quantities of manganese in the diet has important beneficial effects on the quality and texture of egg shells.

IODINE

Iodine is probably the only trace element of which the general public is aware, not because they are interested in iodine other than as an antiseptic but because so much has been written during the last 100 years of the connexion between iodine deficiency and goitre in humans. There are a few reports of goitre in livestock in East Africa, but there is no apparent need for any widespread feeding of iodized salts.

FLUORINE

It is known that fluorine is necessary in small quantities for the proper formation of teeth enamel, but there is little evidence to suggest that there is any need to feed fluorine to livestock in East Africa. On the other hand, in certain areas, the water and soils contain higher amounts than are required by stock, and fluorine intakes are then abnormally high. Excessive intake of fluorine, for any length of time and particularly if it occurs during the period when teeth are being formed, can lead to serious teeth lesions and general toxicity. In certain areas of East Africa one encounters cattle with their teeth worn level with their gums, and it is not hard to imagine the difficulties experienced by such animals in obtaining sufficient food. In addition to the teeth lesions, excessive intake of fluorine can lead to thickening and softening of skeletal structures and to serious interference with the calcification of bones.

TRACE ELEMENTS

Under "trace elements" are included iron, copper and cobalt, all of which are essential to animals in small amounts. An inadequate intake of these minerals leads to pathological conditions of varying severity which may culminate in death.

During the last 20 years, reports of wasting diseases have been received from many parts of the world. The general symptoms are unthriftiness, lack of appetite, emaciation, and often anæmic conditions which may lead to death. There are, of course, other local pathological manifestations of these wasting deficiency diseases, which have been shown to be caused by deficiencies of copper or of cobalt or of both elements together.

Iron

Iron is an essential constituent of the body and is particularly important as a component of hæmoglobin. It plays a vital significance in all living processes concerned in oxygen transportation, as well as in the metabolism of food nutrients within the body cells. Deficiency causes anæmic conditions in animals and chlorosis in plants.

This element forms only 0.004 per cent of the body. Most East African grazings contain sufficient iron, and herbivora usually supplement their feed supplies from soil, either eaten deliberately or ingested accidentally whilst grazing.

In East Africa lack of iron, sufficient to produce anæmic conditions, is most likely to occur when suckling piglets are kept exclusively on cement floors. This type of anæmia can be prevented by painting the sows' udders daily with a solution containing 3½ oz. ferrous sulphate, ½ oz. copper sulphate, dissolved in 6 fluid oz. of water, to which is then added 6 fluid oz. of molasses.

Copper

In addition to wasting symptoms, lack of copper in cattle and sheep is often associated with unco-ordinated muscular movements, stringy wool, and hair depigmentation in cattle. Copper is essential for the utilization of iron in the formation of hæmoglobin. When hæmoglobin is de-graded in the body it is converted into hæmosiderin, and this product can accumulate in various organs of cobalt-deficient animals. This suggests that copper is essential for the re-utilization of iron released during the normal breakdown of hæmoglobin.

Since anæmia is not a constant feature of copper deficiency in ruminants, and because copper deficiency symptoms can be well advanced before anæmia develops, it is possible that copper may play some other essential rôle than in assisting the utilization of iron. Variations in the symptoms of deficiency, between species and also between animals of different ages of the same species, may be due to differences in the functions of copper.

In addition to the deficiency symptoms which arise from an absolute shortage of copper in the grazings, conditioned deficiences have been reported from pastures containing normal amounts of copper, and it appears that other elements, if present in excessive amounts, can interfere with copper utilization. An example is the copper deficiency symptoms on pastures which contain normal copper but abnormally high amounts of molybdenum.

East African experience suggests that copper deficiency may be a nutritional factor limiting stock production in certain areas, particularly in the Rift Valley, the Laikipia Plains and the foothills of certain mountains. Work on this is progressing, but it also appears that a conditioned copper deficiency, due to high molybdenum intake, may be a factor in certain other areas. Deficiency can be cured or prevented by feeding licks containing copper sulphate, and many commercial licks are formulated to provide an adequate supply of this element.

Cobalt

Deficiency of cobalt is also responsible for wasting and emaciating diseases. Sheep are more susceptible than cattle, but, in both species, the clinical picture is that of chronic starvation, often in the presence of apparently adequate grazings. The symptoms are often more pronounced following the flush of spring grass growth.

In East Africa "Nakuruitis" was at one time thought to be due to shortage of iron, but was later identified with cobalt deficiency. This disease may either run a slow debilitating course or may cause rapid loss in weight and finally death. It can be cured by feeding licks containing cobalt, or by removing stock to unaffected areas.

The exact rôle of cobalt in ruminant nutrition has not yet been satisfactorily worked out, but recent evidence suggests that cobalt must be given via the mouth because it forms an essential nutrient for ruminal bacteria. It is also apparent that the ruminal bacteria convert the cobalt of the food into vitamin B_{12} for absorption and use by the animal.

The discovery of the importance of cobalt in ruminant nutrition may be of interest because it was first found that certain limonites as well as iron compounds were of value in preventing or curing wasting diseases in Australasia. It was then noted that different samples had different prophylactic values, and further work indicated that the curative agent was an impurity concentrated in the fraction containing zinc, cobalt, nickel and manganese. The addition of supposedly pure nickel oxide to deficient diets cured the wasting disease, but subsequent investigations showed again that the efficacy of nickel salts differed between samples. A co-operative study then showed that cobalt, present as an impurity in the nickel oxide, was really the responsible element. In fact, the whole story of cobalt and copper deficiencies could not be elucidated until modern spectrographic analyses had been developed. It is interesting that, over 2,000 years ago, Sophocles attributed the fall of Thebes to the pestilence and famine that followed heavy death rates in stock caused by unknown factors in the luxuriant pastures. Modern work on the cobalt-copper wasting disease pays tribute to his powers of observance and suggests an explanation of his observations.

POTASSIUM PERMANGANATE AS A SEED BED TREATMENT AGAINST DAMPING OFF IN PINES

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Potassium permanganate has been widely used, particularly in Africa and India, for the prevention of damping off in seedlings in forest nursery seed beds. In Kenya, a "pink" solution of the salt is often applied regularly to the seed bed as a preventive for damping off, and in the event of a serious attack, this solution is strengthened until it is "almost black", in order to check the spread of the disease.

Local opinion as to the effectiveness of this measure varies considerably, but little experimental work seems to have been carried out to check its efficiency. The earliest account of the use of potassium permanganate for control of damping off that has been traced is that of Spaulding [1] who tried it with inconclusive results. Later, Delevoy [2] used it as a seed bed disinfectant before sowing and claimed a reduction of damping off through its use. Cunningham [3], remarks that potassium permanganate can be used as a substitute for Cheshunt compound, but gives no account of experimental work. More recently, it is said to have been used with success to control damping off in pine seedlings in Southern Rhodesia [4].

During the past year an experimental programme has been completed in which a range of fungicides were tested for control of damping off in pine seedlings: potassium permanganate was included in the compounds on trial, and the results obtained from the use of this compound will be discussed below.

Experimental Procedure

Five experiments with potassium permanganate have been carried out, in the glasshouse, frame, laboratory or in the nursery. These experiments have been conducted under conditions calculated to promote a high incidence of disease; thus, soil known to contain the casual agents of damping off was used, together with a fairly heavy watering programme and a high sowing density. Seeds of either *Pinus patula* or *Pinus radiata* (the two pine species most commonly planted in Kenya) were used experimentally, a constant number being sown in each plot, which were then covered with soil known to contain the casual agents of damping off. The plot units used for small-scale experiments under glass or indoors were small seed boxes giving a soil surface of 7 in. by 8 in.; these were arranged in randomized block designs with from five to seven replications. In the nursery a similar experiment design was adopted, but plots were larger (18 in. × 18 in.) being based on a seed bed subdivided by wooden partitions.

Counts were made for disease between one and two weeks after complete emergence, these were divided into records for healthy and diseased plants for every plot, which with the numbers of seeds originally planted, were used to calculate percentage values for total seedling loss and post-emergence loss (damping off). The results were then analysed statistically in the usual way.

Diseased plants in all experiments were examined for pathogens, and *Rhizoctonia solani* Kühn, and *Pythium ultimum* Trow, were regularly isolated. These fungi were also tested for pathogenicity to pine seedlings grown under sterile conditions, with positive results.

Potassium permanganate was used in these experiments as an "almost black" solution (0.6 per cent) such as used in practice to check outbreaks of damping off. The solution was applied every two days in the small experiments and every week in the nursery experiment.

Results and Discussion

The results of these experiments, with respect to potassium permanganate, are given in Table I. Values for damping off are given as a measure of disease control obtained, while those for total seedling loss (which include loss due to the proportion of non-viable seed in the batch sown) give the overall practical effect of the treatment. Both *P. patula* and *P. radiata* seeds used experimentally had germination of about 85 per cent.

No indication of disease control has been obtained in any of these experiments, indeed, in two out of three experiments in which *P. patula* has been used, marked increases in loss have been recorded. A careful examination of the seedlings in these experiments gave no evidence of phytotoxic effects derived from the treatment, which might have caused such losses. However, when soils receiving potassium permanganate were examined at the end of experiments it was found that the soil pH had risen following treatment from 6.8 to 7.8. Such an increase in alkalinity could be accounted for by the rapid reduction of potassium permanganate in the soil.

The researches of Roth and Riker [5] in the U.S.A. have shown that a rise in soil pH can favour increased losses in conifer seedlings from damping off caused by *R. solani* and *Pythium irregulare*. As similar pathogens are active in the present experiments it seems likely that the increases in seedling loss following permanganate treatment are a direct result of increased soil alkalinity.

Potassium permanganate has also been included in three small field trials carried out on forest stations under conditions of normal practice. No improvement in seedling populations have been obtained through potassium permanganate treatment in these trials.

The sum of these results clearly indicate that potassium permanganate is of little value as a seed bed fungicide locally, indeed there is some reason to believe that increases in disease loss can follow the application of this treatment.

I wish to thank Mrs. G. B. Wallace of the Plant Pathology Laboratory, Lyamungu, for her assistance in identifying the pathogens.

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TABLE I.—EFFECTS OF SEED BED TREATMENT WITH POTASSIUM PERMANGANATE ON DAMPING OFF IN PINE SEEDLINGS

TREATMENT—0·6 *per cent solution of potassium permanganate applied at* 1 *gallon per* 2 *sq. yds. of seed bed*

Experiment No.	DAMPING OFF (PER CENT)		TOTAL SEEDLING LOSS (PER CENT)		Seedling Species	Frequency of application
	untreated	treated	untreated	treated		
1	72·0	76·5	65·9	66·8	*P. radiata*	Every two days
2	27·6	21·7	68·1	66·4	*P. radiata*	,,
3	14·6	59·0**	48·4	86·9**	*P. patula*	,,
4	48·1	54·4	55·4	86·5	*P. patula*	,,
5	22·8	35·5**	60·1	72·0*	*P. patula*	Every week

NOTE.—The suffixes * and ** denote values for treatments which are significantly different from the corresponding nil values at the 5 per cent and 1 per cent levels respectively.

THE OXYGEN CONTENT OF THE WATER IN DAMS IN ANKOLE, UGANDA

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The existence of large numbers of dams in East Africa, constructed primarily for the storage of water, has led to considerable interest being taken in the cultivation of pond fish. Some dams support, without the addition of fertilizers, considerable populations of fish, which can be cropped at intervals to provide valuable proteinaceous food. The yield is high under favourable conditions, but the stocking of dams with fish is not always successful. The E.A. Fisheries Research Organization has investigated many of the conditions which influence the growth of fish in dams; among these, the amount of dissolved oxygen in the water is extremely important. The interaction of several factors affecting the dissolved oxygen content of water has been observed during the course of hydrological investigations over a number of years and a review of the problem may not be out of place.

The reduction of dissolved oxygen in a body of water is brought about by the demand for oxygen by living organisms exceeding the supply. A natural body of water usually contains plankton, both plant and animal, aquatic flowering plants, insects, fish, and throughout the environment, but more concentrated on the bottom deposits, bacteria. All these plants and animals require oxygen for their respiration. Oxygen in the water is also removed by chemical combination with dissolved reducing substances produced by the decomposition of bottom deposits and organic matter. Decomposition continues in the absence of oxygen with the result that reducing substances accumulate in deoxygenated water and constitute an "oxygen debt". This must be paid off before oxygen again becomes available.

Oxygen is supplied mainly by the photosynthetic activity of submerged plants and to some extent by absorption from the air. Both algæ and the larger flowering plants, such as *Ceratophyllum* and *Elodea,* oxygenate the water in which they are growing only if there is sufficient light available. A surface cover on the water, provided by an excessive growth of water-lilies, prevents the penetration of light into the water and severely limits the photosynthetic activities of submerged plants. It should be noted that the oxygen resulting from the photosynthesis of the water-lily leaves themselves passes for the most part from the stomata on their upper surfaces to the air and so contributes very little to the dissolved oxygen content of the water.

The distribution of oxygen within the pond is largely determined by wind-induced currents. The strength of these currents is greatly reduced by the presence of water-lily leaves on the surface. A steady breeze blowing across open water causes a surface drift of water in the same direction, currents below the surface carry water in the opposite direction, thus some mixing of surface and deeper water is brought about. If the body of water is very shallow this mixing may be effective from top to bottom. However, water only a few feet deep may show incomplete mixing and the sub-surface currents which compensate for the wind drift occur at levels between the surface and the bottom. The level at which these currents occur is determined by the strength of the wind and by the temperature conditions obtaining within the pond. Warming of the surface waters by the sun often leads to thermal stratification so that a layer of warm water is formed which overlies the bottom layer of cooler water; this bottom layer may remain undisturbed and become deoxygenated. Thermal stratification arises because cold water is more dense than warm water. The higher the temperature the greater the density difference for any given temperature difference. For example, the density difference between water at 23°C. and 24°C. is twice that between water at 12°C. and 13°C. Thus, under tropical conditions, quite a small temperature difference produces a considerable density difference. Inflows, if they are cool, may bring about thermal stratification as they tend to flow beneath the surface water and accumulate at the bottom.

The data recorded in this paper were collected in August, 1953, and in March, 1954. Besides investigating the temperature and the oxygen content of the water at various levels samples of water were analysed for their alkalinity and their sulphate, phosphate, ammonia, nitrate and calcium content. Data regarding the fish present in these waters were also collected.

Though the dams described occur in the Ankole District of Uganda, similar conditions obtain in many other dams in East Africa.

Nyakashara Dam

This dam is heavily overgrown by blue water-lilies (*Nymphæa*) and species of *Utricularia*. It has little open water. In August, 1953, the temperature of the surface water at 11.00 a.m. was 23.4°C. and was 5°C. cooler at a depth of one metre. The temperature discontinuity occurs close to the surface and can be detected merely by putting one's hand down into the water. This difference in temperature between the surface and bottom waters shows that little or no mixing occurs between these layers. As the dam is heavily overgrown, there is considerable mechanical resistance to any movement of the water, and the large water-lily leaves floating on the water tend to prevent the wind acting on the surface.

The water at the bottom of this dam contained no dissolved oxygen (*see* Table I) and an accumulation of carbon dioxide in the deoxygenated water was indicated by the lower pH of this water compared with that at the surface. In an overgrown dam like Nyakashara, the amount of organic matter present is high and the normal processes of growth and decay create a high oxygen demand in the water. The leaves of the water-lilies prevent the penetration of light, so oxygen production by photosynthesis of subsurface plants is severely limited, thus the replenishment of the oxygen used by the various aquatic organisms is prevented.

Fish traps and nets were set overnight during the visit to this dam in August. Twenty-one mud fish (*Clarias*) were caught but no other species of fish although this dam had been stocked with *Tilapia* by the Game Department six months previously. *Clarias* can breathe air and are often found under conditions of deoxygenation which would be intolerable to gill-breathing fish which are wholly dependent on dissolved oxygen.

Katenga Dam

This is a long winding and narrow dam with fairly high banks. There were patches of water-lilies but most of the water surface was clear. The water was 3.5 metres deep in August, 1953, and was found to be divided sharply into a surface layer about two metres thick and a bottom layer one metre thick. The surface waters were oxygenated with a temperature of 21.5°C. at 10.00 a.m. and 22.0°C. at 4.00 p.m. The bottom layer was deoxygenated and at a temperature of 20.5°C. The surface waters of this dam would normally experience only light winds on account of its narrow winding shape and by virtue of the shelter afforded by the banks, which would allow only a small area to be affected, whatever the direction of the wind. A sudden violent wind, however, could mix thoroughly the waters of this dam. Such circumstances would produce a homogeneous water low in oxygen and rich in carbon dioxide, depending on the concentration of reducing substances in the bottom layer and the relative thicknesses of the two strata. Any gill-breathing fish which had been living in the surface waters would therefore experience a sudden adverse change in the concentrations of oxygen and carbon dioxide. This phenomenon is probably responsible for some of the mass mortalities of fish occasionally reported from lakes and dams.

TABLE I

Hydrological Data from some Dams in Ankole, Uganda, August, 1953.

Road Reference	Name of Dam	Date of Stocking	Whether Stocking Successful	SURFACE WATER		BOTTOM WATER		Depth at Sampling Point
				Temp. °C	O_2 ppm.	Temp. °C	O_2 ppm.	
Mile 6 Mbarara-Ibanda	Nyakashara	13–4–53	No	23·4	8·11	17·7	nil	1·5 metres
Mile 9 Mbarara-Kichwamba	Katenga ..	20–4–53	No	22·0	3·80	20·5	nil	3·5 metres
Mile 8 Lubale-Lwasamaire	Ngarvanya ..	1949	No	21·7	6·25	19·1	nil	5·0 metres
	Kigaga ..			25·0	8·40	24·2	8·10	1·0 metres
Mile 6 Bwezibweru-Ibanda	Lutoma ..	13–4–53	Yes	22·7	4·26	20·7	2·12	2·0 metres
	Mabira ..			21·6	3·86	21·5	3·60	3·0 metres

Tilapia fry were introduced into this dam six months previously, but none of these fish were observed or caught in nets and traps set overnight.

Ngarvanya Dam

There was a certain amount of emergent vegetation (*Typha* spp.) in the shallow water around the edges of this dam, but no plants occurred in the main body of water. The dam was stratified into an upper oxygenated layer about two metres deep and a lower deoxygenated zone about three metres deep, with 2.5°C. difference in temperature between them. The colder bottom layer of water was completely deoxygenated and contained a very high concentration of reducing substances: these samples of water smelt strongly of hydrogen sulphide.

The concentration of sulphates and other salts in the water of both the surface and bottom was very high and there were white incrustations around pools near the edge of the dam where the water had evaporated. This concentration of dissolved salts provide ample raw material for the production of the reducing substances observed; these were present in concentrations sufficient to render the water foul smelling and toxic.

This dam was stocked with *Tilapia* in 1949, but no fish were found.

Kigaga Dam

No water-lilies were observed on this dam, but a dense growth of submerged vegetation, mostly *Ceratophyllum*, covered the bottom. The water was thermally stratified. In March, 1954, there was a difference of over 2.0°C. between the surface and bottom waters although the depth was only 1.0–1.5 metres. The cold bottom water was however well oxygenated. The presence of well-oxygenated water below the thermocline distinguished this dam from the others already described.

This dam had not been stocked with fish and no experimental fishing was carried out on it.

Lutoma Dam

Similar conditions to those found in Kigaga Dam obtained in Lutoma. Extensive beds of subsurface vegetation occurred on the bottom; *Nitella* was the commonest plant present. In spite of thermal stratification, the bottom water was well oxygenated.

The absence of water lilies in these two dams allowed subsurface vegetation to flourish which kept the water below the thermocline in a well-oxygenated condition.

Lutoma Dam had been stocked with *Tilapia* six months previously; several shoals of small fish were observed. Some of these fish were caught in a seine net and identified as *Tilapia leucosticta*.

Mabira Dam

There was a good deal of water-lily growth around the edge and in the shallow upstream portion of this very large dam but the deeper half consisted of clear open water which contained a larger population of planktonic algæ, mostly diatoms. In August, 1953, the open water showed no temperature stratification and was oxygenated throughout. The photosynthetic activity of the plankton was responsible, at least in part, for this condition. There was less water in the dam in March, 1954, and temperature stratification was noted, but there was ample oxygen throughout except in the bottom water near the dam wall. Material to construct the dam wall had been taken from this point and so it was much deeper here than elsewhere in the dam. There was a short and violent rainstorm during the time these investigations were being made and the opportunity was taken to see how effectively the storm mixed the water. The data are shown in Table III. The dam was about 2.0 metres deep over the greater part of its area and down to this depth, mixing was effective. The "tank" near the dam wall, which was an additional two metres deep, remained full of cold deoxygenated water.

This dam had not been stocked with *Tilapia*, however some fish were seen but not identified.

TABLE II

Hydrological Data from some Dams in Ankole, Uganda, March, 1954.

Name Dam	Depth at Sampling Point	SURFACE		BOTTOM	
		Temp. °C	O_2 ppm.	Temp. °C	O_2 ppm.
Nyakashara	1·0 metres	23·0	1·43	20·0	nil
Katenga	3·0 metres	24·4	3·87	21·6	nil
Kasongi	1·0 metres	22·6	6·20	20·6	4·05
Kigaga	1·0 metres	26·0	13·00	23·7	2·58
Lutoma	1·0 metres	23·5	5·50	22·6	3·18
Mabira	2·0 metres	23·8	6·00	23·1	2·50

Kasongi Dam

This dam, which had been constructed recently, contained only sufficient water, in March, 1954, to fill the tank region, Water-lilies had not yet established themselves and the dam contained no bottom-growing plants and a negligible amount of phytoplankton. The water was thermally stratified and showed a difference of 2.0°C. between the temperature of the surface and bottom water, but was well oxygenated throughout.

The water in this dam was cream coloured and very turbid owing to a collodial suspension of the clay exposed by the excavation. Subsurface vegetation could not grow in such turbid waters owing to lack of light. The amount of biological activity in this dam was very low and the absence of living organisms requiring oxygen no doubt accounted for the well-oxygenated condition of the bottom water.

DISCUSSION

Oxygen depletion in the waters of ponds and dams occurs when the rate of supply is lower than the rate of consumption. Oxygen is supplied either from the air or by the photosynthetic activities of aquatic plants, and the distribution of dissolved oxygen within the pond is controlled largely by wind-induced currents. The data from the Ankole dams show the balance achieved by the interaction of the various factors which influence oxygen supply and demand.

TABLE III

The depth of circulation of the water in the "tank" region of the Mabira Dam, Ankole, Uganda, caused by a storm.

Depth in the Tank of the Dam	1400 HRS. BEFORE RAINSTORM		1700 HRS. AFTER RAINSTORM	
	Water Temp. °C.	Dissolved Oxygen ppm.	Water Temp. °C.	Dissolved Oxygen ppm.
Surface ..	25·4	7·80	24·4	6·50
1 metre ..	23·3	nd.	23·8	5·45
2 metres ..	22·7	2·32	23·0	3·71
3 metres ..	22·6	1·47	22·6	1·53
4 metres ..	22·2	nil	22·2	nil

nd.—not determined

The Mabira Dam was the only one in which the depth and area were such as to allow complete mixing of the water by the wind. The water surface was free from vegetation and wind action was therefore unhindered. Photosynthetic activity by the phytoplankton was sufficient to oxygenate the water adequately, although the oxygen demand was sufficiently high to cause deoxygenation in the water of the "tank" region where shading and limited circulation reduced the supply of oxygen.

The cover of water-lily leaves on the surface of Nyakashara Dam had an adverse effect on the oxygen content of the water. The wind-induced circulation was not effective owing to this cover. In addition, the transmission of light was impeded by the leaves, and no vegetation was found beneath the surface. The supply of oxygen was therefore severely limited. The oxygen demand however was high. The bottom deposits were composed largely of debris from the water-lilies. The decomposition of these deposits consumed oxygen, the supply of which was so limited that severe depletion of the oxygen content of the water resulted.

A similar depletion of oxygen was found in the bottom waters of Katenga Dam. The cover of water-lilies was not complete and there were lagoons of open water present. However, no vegetation was found growing on the bottom. Its high banks and narrow, winding shape sheltered this dam from the wind, and the strength of the resultant currents was considerably reduced. The patches of open water were oxygenated at the surface but as the oxygen supply was restricted, depletion occurred in the lower waters.

Kigaga and Lutoma Dams contained water adequately oxygenated throughout. Owing to the mat of bottom-growing vegetation found in both these dams, complete circulation of the water by the wind was considerably hampered. This effect is shown by the difference in temperature between the surface and bottom water. The surface was free from water-lilies, and the unimpeded passage of light in the water allowed considerable production of oxygen by the subsurface vegetation. There is no doubt that the successful stocking of fish in Lutoma Dam was greatly facilitated by the photosynthetic activities of the bottom-growing water weeds.

The oxygenated condition of the water in Kasongi Dam, in spite of the stratification of the water and the absence of subsurface vegetation, is clearly due to the lack of organic matter present. In this instance, the limitations put upon the supply of oxygen by the extreme turbidity of the water and by thermal stability are offset by the low rate of consumption.

Ngarvanya Dam is somewhat sheltered by high ground, and the force of the wind at the water surface is therefore partially reduced. The currents caused by the wind were only effective in mixing the upper layers of water in this dam. There was no vegetation in the main body of water and therefore the depth to which mixing was effective depended on three factors only: the strength of the wind at the water surface, the effective surface area, and the change in density caused by temperature differences between the surface and bottom waters. At the time of sampling, these factors had a value such that mixing was only effective down to a depth of two metres, although it is clear that a change in the relative value of any of these factors, would result in an alteration in the position of the thermocline. Only the water above the thermocline was oxygenated; therefore any change in its position would have a considerable effect on the amount of oxygenated water present. The waters of this dam contained an unusually high concentration of dissolved salts. This indicates that the dam was probably receiving significant amounts of seepage water. The relatively low temperature of the bottom water in this dam and its high content of reducing substances is understandable if underground water is a source of supply. Ngarvanya Dam was the deepest of those sampled and the data indicate that its small area, relative to its depth, is the most important factor preventing complete circulation and oxygenation of the water.

The most effective factor in disturbing the balance between oxygen production and utilization in small dams, is the surface cover provided by the leaves of the water-lily. Although perhaps pleasing to the eye, a profusion of this plant in a dam has a disastrous effect on the oxygen content of the water.

SUMMARY

The dissolved oxygen content of the water in seven dams in Ankole, Uganda, was examined in August, 1953, and March, 1954. The factors influencing the supply, distribution and demand of oxygen are described and their relative importance discussed. The resultant effect is illustrated by the success or otherwise of fish-stocking carried out in four of them.

ACKNOWLEDGMENTS

I am very grateful to the Director and Staff of this Organization and to the Department of Game and Fisheries, Uganda, for much helpful discussion and for assistance in the field.

THE COTTON RED BOLLWORM PROBLEM IN SOUTHERN TANGANYIKA

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The red bollworm of cultivated cotton, *Diparopsis castanea* Hmps. was recorded in July, 1946, in the Lindi–Rovuma area bordering upon Portuguese East Territory [1]. This appearance of *D. castanea* in Tanganyika was correlated with a northward extension of cotton growing in Portuguese territory during the war years [2] and led to the establishment of a quarantine belt by the Tanganyika Government as a measure against the further northward spread of the insect into the cotton-growing areas of Eastern Province (Fig. 1). In 1947 Jepson [3] discovered a *Diparopsis* species on a wild Malvaceous plant, *Gossypioides kirkii*, which has a discontinuous distribution along the Cretaceous plateau of the Tanganyika hinterland stretching from the Portuguese border through the quarantine belt and into and beyond the Eastern Province cotton areas. Fears were expressed firstly that the *Diparopsis* on *G. kirkii* might be the same species as that on cultivated cotton, and then secondly that even if it were a different species *D. castanea* might be able to extend its range breeding on the chain of *Gossypioides* plants in the quarantine zone.

In 1951 permission was given to the Overseas Food Corporation to make trial plantings of cotton in the area being developed by them at Nachingwea in the Southern Province and which is situated just inside the quarantine belt. As Nachingwea is about 90 miles from the Portuguese border it was hoped that the crop would remain free of *D. castanea* and would not constitute a threat to other cotton areas 140 miles to the north.

The Development of Red Bollworm as a pest of cultivated cotton in Southern Province

Following the first report of red bollworm in 1946 [1] further searches were made the year after [3] in which the insect was found at Mkwela, near Mahiwa, on the Masasi–Lindi road and at Namatola on the Lukuledi–Ruponda road. In this latter year cotton growing north of the Lindi–Lukuledi road was officially prohibited by the establishment of a quarantine zone.

During 1951 a survey made at Nachingwea, where cotton was being grown for the first time, revealed a heavy infestation of *Diparopsis castanea* on about 50 acres of cultivated cotton at Chiungutwa, 18 miles south of Masasi and approximately 48 miles from Nachingwea. No red bollworm was present on cotton at Lukuledi in that year nor in small plots being cultivated against regulations inside the quarantine belt near Ruponda. No cotton was found eastwards along the Nachingwea–Lindi road as far as Mtama nor at Newala in the south.

During 1952 cotton was again planted at Nachingwea by the Overseas Food Corporation, 75 acres on Farm 2 and 50 acres on Farm 7. Seven red bollworm larvæ were subsequently found from regular weekly samplings on Farm 2 and six from fortnightly samplings on Farm 7. All available evidence indicates that no cotton was grown in 1952 between Nachingwea and the Portuguese border in a line passing south-eastwards through Masasi and Newala. It would thus appear that the Nachingwea infestation derived from that recorded in the previous year at Chiungutwa, 48 miles away, the intervening dry season being passed in the diapausing pupal stage in the soil.

In the 1953 cotton season at Nachingwea only one red bollworm larva was found, significantly perhaps on Farm 7 where the insect had been recorded the previous year. In 1954 red bollworm was recorded at Nachingwea in March, very early in the cotton season, and in the first instance on and near where it had been found in the two previous seasons, indicating that the infestation had not been brought in afresh from outside sources. By mid-June larvæ were obtainable with varying degrees of ease in all areas planted, with the exception of Farms 14 and 15 in the extreme east. The conclusion was drawn that further attempts at cotton growing would only lead to greater populations of *Diparopsis*, probably reducing the yield to uneconomic levels and also presenting a still greater threat to the cotton growing in the Eastern Province.

Cotton growing will be discontinued at Nachingwea as it has been decided to maintain the present quarantine zone.

Dusting at weekly intervals with a mixture of 10 per cent DDT and 3 per cent gamma BHC at a rate of 16 lb. per acre had no effect in reducing red bollworm infestation although it had an appreciable effect on American and spiny bollworms.

	Bollworms Per Acre		
	American	*Spiny*	*Red*
12 April—Control	670	214	0
Dusted	407	415	10
20 April—Control	554	155	87
Dusted	388	68	68
28 April—Control	214	106	272
Dusted	155	29	350

The characteristic diapause behaviour of *D. castanea* occurs in the Southern Province, some early larvæ producing long-term pupæ and all late ones giving long-term pupæ.

Collection date of D. castanea *pupæ*	*Per cent emergence as adults*
April 23–26	65 (late May)
May 16	7 (mid-June)
June 30	0 —

Extensive searches in 1954, in which well-established cotton areas to the east of Nachingwea in the Mtama, Lindi, and Mingoyo districts and to the west at Tunduru were examined, showed only two slight infestations by *Diparopsis*. The recorded distribution of *Diparopsis* since 1946 is shown in Fig. 2.

In connexion with the south-north spread of the insect it is of interest that the prevailing winds from April to July, when the cotton would normally be in a receptive condition, are from the south. A clear example of the ability of the insect to extend its range northwards occurred at Newala, 1954, where a trial plot of cotton, less than one acre in extent, was found to be heavily infested in mid-June. As no cotton had been grown in the district for over four years the infestation must have derived in the current season from plantings in Portuguese East Territory, the nearest of which were reported about 15 miles away in a direct line south of Newala.

The Relationship between Diparopsis castanea *and the wild plant* Gossypioides kirkii

Specimens of a red bollworm larva have been taken from *G. kirkii* during the past few years at a number of places in the southern and eastern provinces (Fig. 1). Only one specimen has so far been reared through to the adult stage and this has been recognized as a new species, *D. gossypioides*, entirely distinct from the cultivated cotton bollworm, *D. castanea* [4]. During extensive searches in 1954 four larvæ were taken from *G. kirkii* only ten miles from Nachingwea where heavy populations of *D. castanea* were present on cultivated cotton. The discovery is of importance in that if *G. kirkii* were an alternate host plant of *D. castanea* then that species should have been found on it at Nachingwea. Examination of the largest of these specimens, which by comparison with previously caught larvæ undergoing pupation is believed to be full grown, proves that it is readily distinguishable from that of *D. castanea*. Differences are listed in Table I and illustrated in Plate I.

Larvæ of *D. castanea* were first found at Nachingwea in 1954 on 27th March indicating that emergence occurred at the end of February—beginning of March. *G. kirkii* in the district was only showing buds towards the end of April and bolls were not present until the end of May. Thus suitable food from *G. kirkii* for *D. castanea* would not be present during the first flight of moths except perhaps for a very few individuals which might emerge about two months late.

With the previous identification of the one adult as a distinct species, the fact that larvæ on *G. kirkii* are extremely difficult to find, even in an area where large populations of *D. castanea* exist, the larval differences recorded above and the disjunction between the first flight of *D. castanea* and early bolling in *G. kirkii* it must be concluded that *D. castanea* is unable to exist or extend its range on *Gossypioides*. As stated previously by Pearson and Mitchell [5] spread of *D. castanea* is dependent on the extension of cotton cultivation.

The possibility of D. castanea *being able to establish itself in Eastern Province*

The occurrence of *D. gossypioides* larvæ north of Utete (Fig. 1) may have some bearing on the unsolved question if, given the opportunity, *D. castanea* could establish itself in the Eastern Province of Tanganyika. Both *D. gossypioides* and *D. castanea* larvæ undergo a long-term diapause in the pupal stage which is correlated with their adaption to a plant of annual habit and to a long dry spell between seasons. The fact that *D. castanea* produces a long-term pupa in the Southern Province, in co-existence with *D. gossypioides* indicates that it may be able to do the same in other areas where *D. gossypioides* exists and must necessarily produce long-term pupæ in order to survive. Comparison of mean maximum and minimum temperatures at Nachingwea, where *D. castanea* does undergo diapause, with those for areas further north (Table 2) shows that conditions are not vastly different and that diapause might be possible in those areas. The cultivation of both rain and flood-grown cotton in adjacent areas in the Rufiji basin extends the cotton season from March or April to December, leaving only three to four months as a close season. These observations, in conjunction with the lack of precise information on the flight range of *D. castanea*, indicate that it is still necessary to maintain the existing quarantine zone as a barrier against the pest.

SUMMARY

1. An account is given of the appearance and spread of red bollworm in the Southern Province of Tanganyika, with particular reference to cotton plantings at Nachingwea by the Overseas Food Corporation.

2. Reference is made to the 140 miles' wide quarantine zone set up in 1947 as a measure against the northward spread of red bollworm into Eastern Province cotton areas.

3. Evidence is brought forward suggesting that a flight range of about 50 miles is possible.

4. The relationship between *Diparopsis castanea* and the previous suspected host plant, *Gossypioides kirkii*, which has a discontinuous distribution throughout the quarantine zone, is discussed. It is concluded that *D. castanea* does not breed on *G. kirkii* in the field and that its spread is due to extension of cotton cultivation.

5. A red bollworm larva found on *G. kirkii* in the Nachingwea district where *D. castanea* was abundant on cultivated cotton is compared with the latter insect and shown to be readily distinguishable.

6. The possibility of *D. castanea* being able to maintain itself in the Eastern Province of Tanganyika, were it ever introduced, is discussed. The evidence against this is not conclusive and together with the lack of precise knowledge of the flight range of the insect indicates the desirability of maintaining the present quarantine zone separating Southern and Eastern Province cotton areas.

ACKNOWLEDGMENTS

Thanks are due to the Provincial Agricultural Officer, Southern Province, and to his staff for the assistance they gave in searching for red bollworm larvæ.

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TABLE I

DIFFERENCES BETWEEN LARVA OF DIPAROSIS CASTANEA AND THAT OF D. GOSSYPIOIDES

1. *Length*:
   - *D. castanea*—Approximately 30 mm.
   - *D. gossypioides*—Approximately 17 mm.

2. *Markings*:
   - (*a*) *Dorsal red markings.*
     - *D. castanea*—Have appearance of a letter W, i.e. with sides not parallel to medial mark.
     - *D. gossypioides*—Have appearance of letter E on its back, i.e. with sides parallel to medial mark.
   - (*b*) *Dorsal prothoracic shield.*
     - *D. castenea*—Uniformly dark in colour; darker than head capsule.
     - *D. gossypioides*—Tan-coloured and of same depth of colour as head capsule. Anterior border darker than remainder and with two dark oblique marks posteriorly near middle line.
   - (*c*) *Anal plate.*
     - *D. castanea*—Grey-brown in colour with a dark longitudinal medial band.
     - *D. gossypioides*—Dark tan in colour and without a conspicuous medial band.
   - (*d*) *"Coxal plate", 10th abdominal segment.*
     - *D. castanea*—Plate conspicuous. Mid-tan-coloured with a darker border.
     - *D. gossypioides*—Plate inconspicuous. Light-tan-coloured and without a dark border.

3. *Setal differences*:
   - (*a*) *Position of seta SD1 on prothorax.*
     - *D. castanea*—Separate from dorsal plate.
     - *D. gossypioides*—Included in dorsal plate.

(*b*) *Mesothoracic setæ.*

D. castanea—Setæ L3, SD1, SD2 and D2 on small, relatively inconspicuous pinnaculi. Diameter of these pinnaculi much less than that of Seta L1.

D. gossypioides—Setæ L3, SD1, SD2 and D2 on conspicuous, large dark pinnaculi. Diameter of these pinnaculi equal or approximately equal to that of Seta L1.

(*c*) *Seta L2 on 9th abdominal segment.*

D. castanea—On conspicuous chitinized tubercle.

D. gossypioides—Tubercle not darkly chitinized.

4. *Shape of spiracles.*

D. castanea—Elongate oval.

D. gossypioides—Obovoid.

TABLE II

TEMPERATURES AT STATIONS IN SOUTHERN AND EASTERN PROVINCES

Mean Monthly Temperatures in ° C.

Month	Nachingwea (S. Prov.) 1951 (6)			Morogoro (E. Prov.) 1951 (6)			Mpanganya (E. Prov.) Nr. Utete 1947 (7)		
	Max.	Min.	Diff.	Max.	Min.	Diff.	Max.	Min.	Diff.
May ..	28·7	16·6	12·1	28·1	18·6	9·5	32·0	22·5	9·5
June ..	28·4	15·8	12·6	27·0	16·1	10·9	32·3	18·3	14·0
July ..	28·4	15·2	13·2	27·5	15·1	12·4	31·3	17·9	13·4
August	29·9	16·2	13·7	28·7	16·0	12·7	32·4	17·3	15·1
Sept. ..	31·6	17·2	14·4	29·4	17·1	12·3	30·1	18·8	11·3

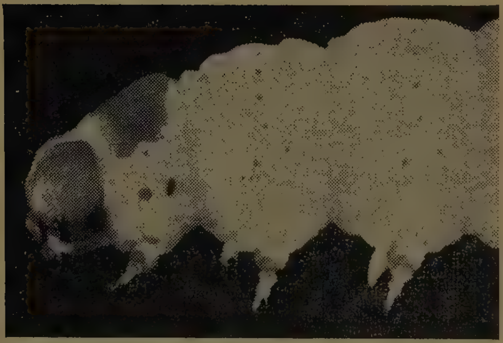


Plate 1a—Diparopsis castanea. Left anterior view x 10

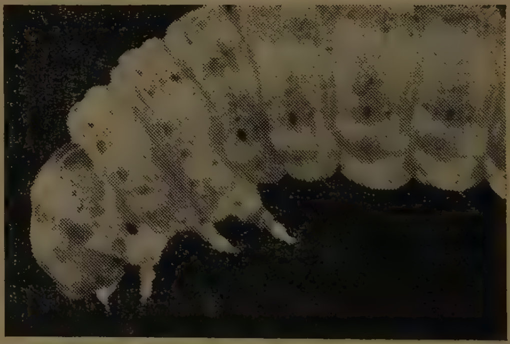


Plate 1c—Diparopsis gossypioides. Left anterior view x 10

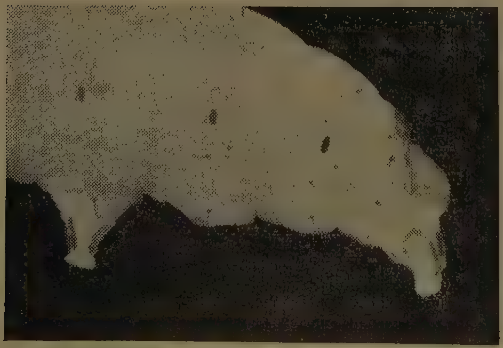


Plate 1b—Diparopsis castanea. Left posterior view x 10

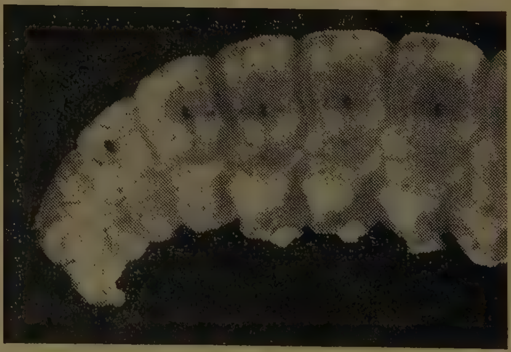
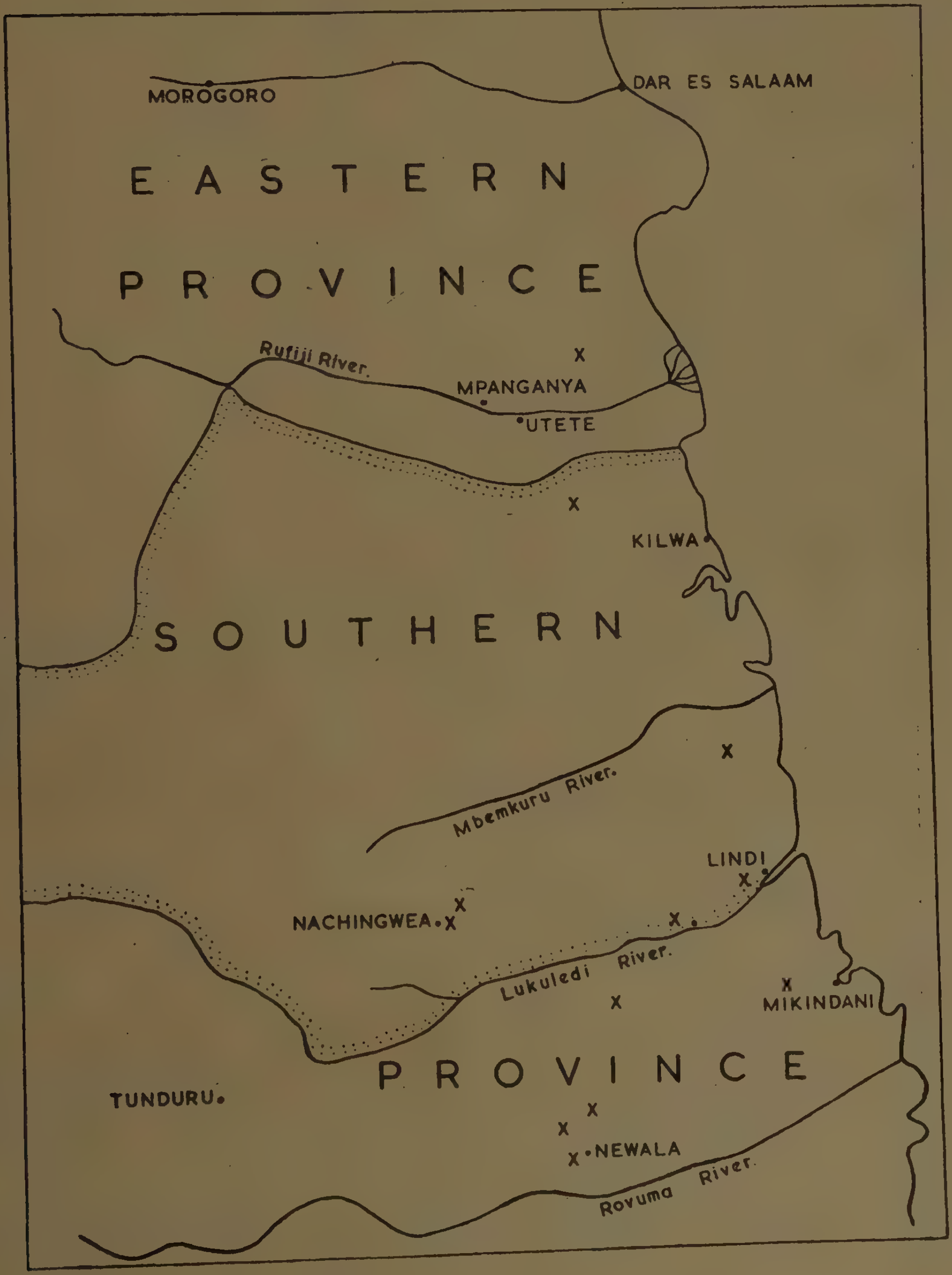


Plate 1d—Diparopsis gossypioides. Right posterior view x 10



X D. gossypioides.

∴∴ Boundary of quarantine belt.

Fig. 1—Recorded distribution of Diparopsis gossypioides in relation to quarantine zone

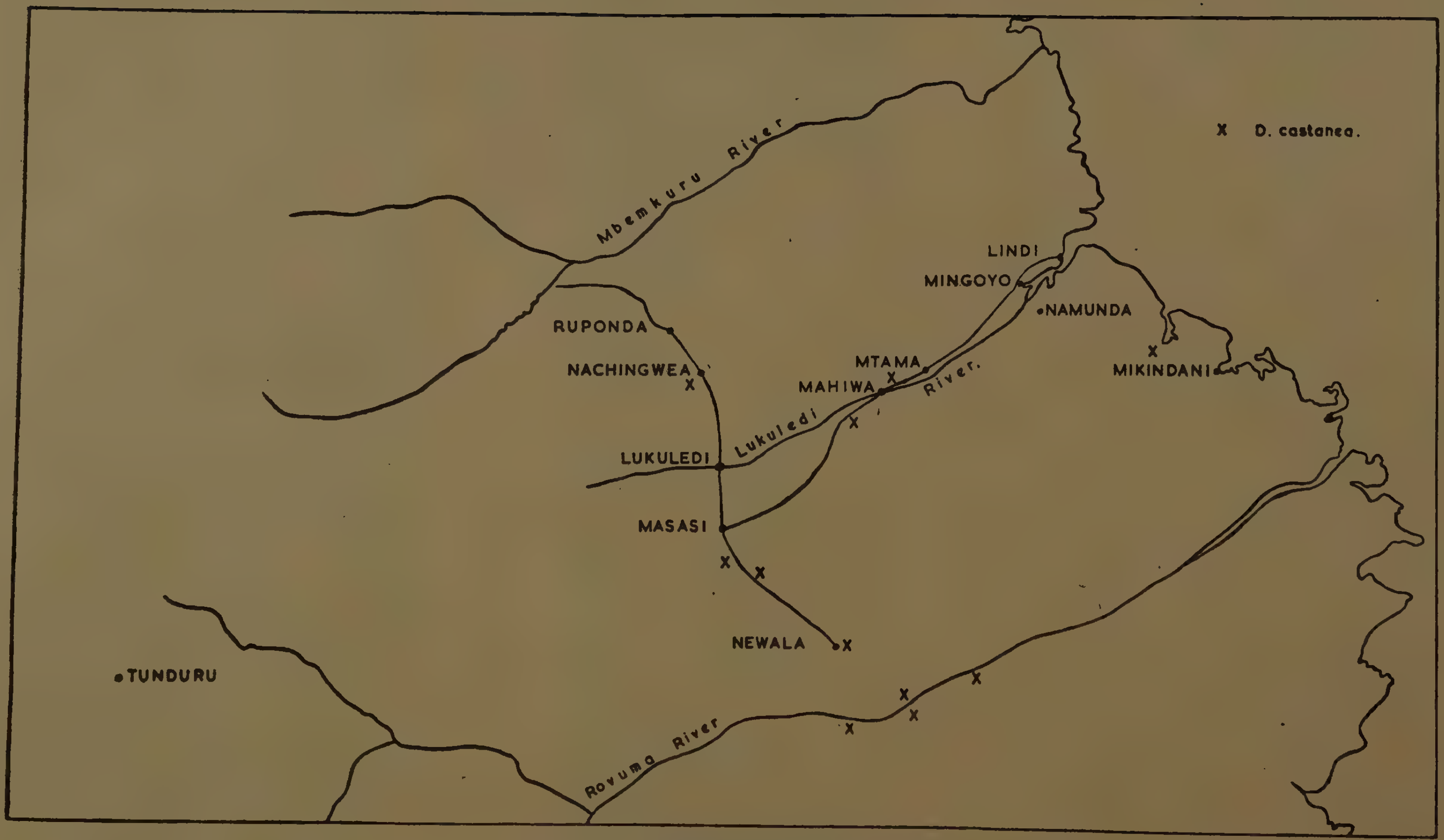


Fig. 2—Records of Diparopsis castanea since 1946

NUTRITIVE VALUE OF SUNFLOWER HEADS

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Practically all the previous work on the nutritive values of sunflowers has been done either on silage or on the seed itself. Several comparative studies of maize and sunflowers for silage have been conducted in Germany and the general conclusion is that sunflowers produce at least an equal, if not greater, dry matter bulk per acre. Bürger and Blöcker (1931) found sunflowers well suited for ensilage if cut not later than full bloom and, at this stage their yield exceeded that of maize. Brigl and Windheuser (1931) also found sunflowers to be higher yielders than maize but suggested they were not so satisfactory for ensilage because of their high fibre contents and hence their lower feeding values. Könekamp (1931) in East Germany showed sunflowers to be as productive as maize for ensilage and preferable on drier soils. Kirsch and Jantzen (1934) reported that in a comparative cultivation trial, maize and sunflower, when conserved as silage, were almost equal as starch equivalent producers. Konkl and Jirasek (1938) gave the following results from a digestibility trial in which both silages were readily eaten:—

	D.P.	*S.E.*
Maize silage ..	2.46	49.2
Sunflower silage	4.19	47.7

Atkeson (1935) reported that on the basis of total digestible nutrients consumed and the resulting milk production, sunflower silage was equivalent to maize silage but palatability tests showed that cows preferred the latter. Apart from work by Rennie (1938), who showed that black sunflower heads, as meal, were suitable for dairy cows as part of the concentrate ration, no published data can be found concerning the feeding value of sunflower heads, and it was with the object of remedying this deficiency that the present study was undertaken.

The feeding value of sunflower heads must, of course, vary considerably, depending on the time of cutting, the extent of seed-shedding and the length of stem included. It will be understood that the amount of seed is the major factor influencing the starch equivalent of sunflower heads because seeds containing about 30 per cent oil will have a starch equivalent of about 100.

The sunflowers used in this trial were grown on Kitale Agricultural Station and were fully mature when harvested and it was estimated that about 5 per cent shedding had taken place. Approximately 30 per cent of the seeds had fallen out or were lost before grinding. It was noted that the seeds were not fully filled, probably because the plants were exposed to a six weeks' drought, from the end of August to the middle of October.

A digestibility trial was conducted with two grade Merino wethers. After a preliminary feeding period which lasted a fortnight, a twelve-day feeding trial was carried out with the ground sunflower heads. The sunflower heads, which were fed together with a basal ration of chaffed meadow hay of known digestibility, provided one-third of the total diets and the actual rations fed to the two sheep were:—

Sheep A—200g sunflower heads + 400g meadow hay daily.

Sheep B—250g sunflower heads + 500g meadow hay daily.

The sheeps' fæces were collected daily, duplicate 5g samples were analysed for protein and duplicate 100g samples were dried, at 105° C. for 24 hours, for dry matter determinations. In addition, a fixed proportion (one-tenth) of the fæces from each sheep was dried daily at 50° C., bulked, milled and analysed for the other proximate constituents. Duplicate 100g samples of the sunflower heads and meadow hay were separately dried for 24 hours at 105° C. for dry matter data and further representative samples were taken daily, bulked, milled and analysed for the usual constituents.

When determining the digestibility of a semi-concentrate foodstuff such as sunflower heads it is, of course, necessary to feed it together with a roughage of determined digestibility. The meadow hay used in this trial had the following composition, digestibility and nutritive values:—

Basal Ration of Chaffed Hay

	Analysis %	*Digestibility* %
Crude protein ..	9.97	56.4
Ether extractives ..	2.78	60.3
Crude fibre ..	33.03	66.2
N-free extractives ..	44.70	56.0
True protein ..	8.47	48.6
Dry matter ..	100.00	57.5
Calculated starch equivalent ..		36.2
Calculated protein equivalent ..		4.9

RESULTS

Sheep A—Food ingested: 3,513g hay+1770g sunflower heads (D.M. basis).

Dry weight fæces: 2,210g.

Fæcal crude protein (wet analysis): 226.8g.

Sheep B—Food ingested: 4,345g hay+2,193g sunflower heads (D.M. basis).

Dry weight fæces: 2,622g.

Fæcal crude protein (wet analysis): 261.9g.

Analyses and Nutritive Value of Sunflower Heads

After deducting the fæcal dry matter of the hay portion, calculated from its known digestibility, the following table has been constructed for the ground sunflower head moiety:—

	Analysis %	% *Digestibility* *A*	*B*	*Mean* %
Crude protein ..	14.63	71.4	77.2	74.3
Ether extractives ..	7.19	90.8	89.6	90.2
Crude fibre ..	24.07	39.1	46.8	43.0
N-free extractives ..	45.54	63.7	67.3	65.5
True protein ..	12.58	81.1	85.6	83.5
Dry matter ..	100.00	59.5	64.7	62.1

	Sheep A	*Sheep B*	*Mean*
Calculated starch equivalent ..	50.0	54.1	52.1
Calculated protein equivalent ..	10.3	11.0	10.7

It should be noted that in assessing the starch equivalent of the sunflower heads, it was considered preferable to use the factor 0.58 × crude fibre instead of assuming a V correction factor. As the sunflower heads contained 24 per cent crude fibre, it can be reasonably assumed that no greater error results from the use of this roughage factor than would result from using an estimated V number.

From the figures obtained, it will be observed that the crude protein and ether extractive fractions of the sunflower heads are particularly well digested. Nitrogen-free extractives are digested quite satisfactorily but the crude fibre fraction is dealt with less adequately. The above table shows that ground sunflower heads, containing approximately 70 per cent of the ripened but inadequately filled seeds as well as some six inch of stalk, possessed a feeding value of 10.7 per cent protein equivalent and 52.1 starch equivalent. As has been indicated previously, the feeding value must necessarily be greatly influenced by the amount of seed in the meal. This particular sample cannot be claimed to be a true concentrate; in fact, it is fairly comparable to wheat bran in starch and protein equivalents. It would seem quite possible to produce meals containing about 65 S.E. by including all the seed in the final ground product, and future experiments will seek to determine the separate feeding values of seeds and seedless heads so that nutritive values of heads containing varying percentages of seed can be calculated.

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EFFECTS OF PUCCINIA POLYSORA RUST ON YIELD OF MAIZE

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The rust caused by *Puccinia sorghi* Schw. is commonly present on maize plantings in the area farmed by the Overseas Food Corporation at Nachingwea, in the Southern Province of Tanganyika. By 1952 the destructive rust caused by *P. polysora* Underw. had been recorded in all the East and Central African territories, and a close watch was kept for its appearance at Nachingwea. In early April, 1953, the increasing incidence of rust on the maize crop raised suspicions of the presence of *P. polysora,* and the organism was so identified by the Commonwealth Mycological Institute [1]. It was later found in neighbouring districts in the Southern Province.

In the 1953 season the incidence did not become heavy until the silks were drying, on the majority of the fields, but by maturity most of the leaves were heavily parasitized and large necrotic areas had developed. On later plantings the epidemic began relatively sooner, and such plantings were killed before the normal date of maturity. As a tentative control measure, to reduce any persistence of viable inoculum through the dry season (June–November), all the maize trash after harvest was either burned or buried by deep ploughing, and the planting of out-of-season maize in gardens and labour camps was prohibited. As the Overseas Food Corporation's land at Nachingwea is in a compact block and over 30 miles from any extensive areas of native-grown maize, it was hoped the isolation would at least delay the initial build-up of infection.

Maize is usually planted at Nachingwea in January and early February. For the 1954 season effective rains began early in December (1953) and although large areas of maize were not planted until early January, a few small patches were established on farms, and the usual plantings appeared around labour camps. By the end of January *P. polysora* was universally found on such plantings, and it soon began to spread on to the main crop, so that every field was infected before the tasselling stage. Such small plantings in advance of the main crop, being scattered over the farming area, serve as numerous foci for spread of spores, after a build-up of two or three generations.

The disease incidence increased rapidly, and by the time the silks had dried a number of the lower leaves were completely killed. Subsequently more leaves died, and eventually the whole of the plant tissue—leaves, leaf sheaths and cob sheaths—was killed, often two weeks before the normal maturity date. Later plantings suffered correspondingly more. As the crop died prematurely, extensive lodging was observed, and early harvesting was necessary.

Reduction in Yield Due to the Incidence of the Rust

Two experiments were planned to study the effects of the rust on yield in the 1954 season. One was a trial using a fungicide to achieve complete control, and the other a series of plantings at weekly intervals.

In the first experiment sulphur dust was used as the fungicide, with the same technique as has been used with groundnuts [2]. A proprietary "spreading" sulphur was applied with a rotary hand duster at four-day intervals, from six weeks' age onwards; if more than half an inch of rain fell, the dusting was repeated the following day. Sufficient dust was applied on each occasion to ensure complete coverage of all the surfaces of the plants. The experiment was laid out in the middle of a field of maize, so that uniform epidemic conditions would be assured: the field chosen was planted on the 5th January. The experiment was designed as eight randomized blocks of two plots each (treated and control), with a plot size of eight 34-in. rows, 85 links in length. The plots were widely separated so that no drift of dust to control plots could occur.

The control plots were harvested at 106 days' age, by which time all the plants were completely dead, and considerable lodging had occurred. The treated plots remained green and vigorous until 113 days, when they were harvested because the cobs were fully mature. High winds had caused some lodging on the treated plots, but the plants had rarely broken off completely.

A very slight infection became established on the treated plots, because of their close proximity to the heavily diseased bulk maize, but throughout the growing period the infection was confined to the older, lower leaves. Towards maturity, the infection increased somewhat, but on 13th April (i.e. eight days before the harvest of the control plots), when scorings were made of the rust infection over the experiment, the "rust indices" were 5.96 for the controls and only 1.60 for the treated plots. (The scoring system and "rust indices" are described below.) It is, therefore, considered that a most effective control of the disease was maintained throughout the growing period.

The results of this experiment are presented in Table 1.

Analyses of the carbohydrate, nitrogen and sulphur content of samples of seed from each plot were made in the chemistry laboratories of the East African Agriculture and Forestry Research Organization.

	Carbohydrate	*Nitrogen*	*Sulphur*
	%	%	%
Treated ..	86.9	1.69	0.09
Nil ..	82.7	1.79	0.08

None of these differences approached significance: obviously the increased yield of the treated plots involves a general increase in the protein and carbohydrate and not in an altered ratio between them.

TABLE I.—EFFECTS OF RUST INFECTION ON THE YIELD OF MAIZE (VARIETY KATAMBILI)
(*Nachingwea*, 1954)

	Population/ acre	Yield of seed (lb./acre)	No. of cobs/ plant	No. of seed/ plant	No. of seed/ cob	Shelling percentage	No. of seed/lb.	Bushel weight (lb.)
Treated ..	8,397	2,749	1·11	421	377	81·4	1,320	60·7
Nil	8,475	1,847	0·99	369	368	80·2	1,722	57·9
Significant differences—								
5 per cent	224	399	0·08	52	37	1·3	189	1·2
1 per cent	333	591	0·12	77	55	1·9	280	1·7

These results demonstrate the large loss in yield due to the disease. The loss was 902 lb. seed per acre, which was very highly significant. There was no difference in the populations of the two treatments.

The increased yield of the treated plots is made up in two ways. There is a significant increase in the number of cobs per plant, the increase being 0.12 cobs per plant. This means that a greater number of the plants in the treated plots were producing a second cob bearing seed. The increase in the cobs per plant is reflected in the high number of seed produced per plant on the treated plots, but there is no difference in the mean numbers of seed produced per cob.

The second factor in the yield increase is in the considerable difference in individual seed weight, as expressed by the numbers of seed per pound. This difference of seed weight is also shown by the slight difference in shelling percentage between the treatments.

The heavy incidence of rust also caused a significant lowering of the bushel weight of the seed. This reduction of the bushel weight, and also the decrease in the individual seed weight are normal effects of heavy rust incidence on other cereal crops [3].

Incidence of Rust on Maize Planted on a Series of Dates

Eight plots of maize (variety Katambili) were planted at weekly intervals from 23rd December, with uniform spacing, fertilizer application and cultivation treatments. Each planting was harvested when no green tissue remained on the plants.

Twelve plants in each plot were marked, and at weekly intervals every leaf on each of the plants was examined and scored for the incidence of rust. For the purpose of the scorings only leaves over 12 in. in length were examined: it was found that the plants usually produced five or six shorter leaves before the "1st" leaf, but these soon withered.

The classification used for the weekly scoring was as follows:—

Class 0 No signs of rust incidence.

Class 1 Isolated sori distributed over the leaf lamina.

Class 2 Small groups of sori present in addition to isolated sori. No extensive chlorosis or necrosis present.

Class 3 Larger groups of sori present, with spreading chlorosis, coalescing between large adjacent groups.

Class 4 Sori present all over the leaf lamina. Widespread chlorosis around and between sori and necrosis of margins and tip of lamina. Necrosis amounting to less than 50 per cent of the lamina.

Class 5 Leaf moribund; more than 50 per cent of the lamina necrosed, but some green colour still evident, although chlorotic.

Class 6 Leaf entirely dead, often broken off at the base of the lamina.

From the scorings of 12 plants, a weekly picture of the average plant for each date of planting is obtained. For example, when the first date of planting was 11 weeks old, the state of the average plant was:—

	Total	Class 0	1	2	3	4	5	6
No. of leaves	15·4	1·2	2·6	2·2	2·7	2·7	1·6	2·4

In order to be able to make comparisons of the incidence on the different dates of planting, an arbitrary "rust index" has been devised. This is calculated by multiplying the number of leaves in each class by the class number, and dividing by the total number of leaves. For example, using the figures above:—

$$\text{R.I.}\text{—}\ (1{\cdot}2\times0)+(2{\cdot}6\times1)+(2{\cdot}2\times2)+(2{\cdot}7\times3)+(2{\cdot}7\times4)+(1{\cdot}6\times5)+(2{\cdot}4\times6)\div15{\cdot}4$$

$$\text{R.I.}=3{\cdot}14$$

Thus, for each of the eight dates of planting a weekly "rust index" is obtained; the maximum index with this system being 6, which signifies death of all the leaves on the plant. These calculated indices are presented in Table 2, from which it can be seen that the rates of increase in rust incidence for each planting are very similar.

TABLE 2.—CALCULATED "RUST INDICES" FOR THE INCIDENCE OF RUST ON EIGHT PLANTINGS AT WEEKLY INTERVALS

Age of Planting (Weeks)	PLANTINGS T/1	T/2	T/3	T/4	T/5	T/6	T/7	T/8
1 ..	0	0	0	0	0	0	0	0
2 ..	0	0	0	0	0	0	0	0
3 ..	0	0	0	0	0	0	0	0
4 ..	0	0	0	0	0	0	0·15	0·33
5 ..	0	0	0	0	0·01	0·07	0·45	0·78
6 ..	0	0	0·07	0	0·17	0·46	1·23	1·47
7 ..	0·23	0·10	0·10	0·30	0·62	1·16	2·36	2·10
8 ..	0·52	0·60	0·67	0·70	1·59	2·25	2·83	3·10
9 ..	1·07	1·21	1·47	1·70	2·39	3·48	3·29	3·69
10 ..	1·71	2·13	2·47	2·99	3·84	4·09	4·19	4·32
11 ..	3·14	2·91	3·66	3·91	4·28	4·75	4·52	4·74
12 ..	3·84	4·10	4·46	4·62	5·00	4·98	5·14	5·43
13 ..	4·89	5·02	5·14	5·13	5·33	5·52	5·63	5·90
14 ..	5·49	5·48	5·68	5·57	5·69	5·89	—	—
15 ..	5·89	5·90	—	—	—	—	—	—
16 ..	—	—	—	—	—	—	—	—

Effects of Rust on the Yield of the Weekly Plantings

The yield data for the eight plantings are presented in Table 3. These results show the very heavy losses in yield suffered by the later plantings, which were attacked at earlier stages in their life-cycles. The infection progressively shortened the period until harvest became necessary—when all the plants were devoid of green tissue and extensive lodging was occurring. As with the "blanket fungicide" experiment, the higher yields of the earlier plantings are in the main made up by the higher number of cobs per plant, and by the higher individual seed weight. Again the progressive reduction of bushel weight is evident.

TABLE 3.—EFFECTS OF RUST INFECTION ON THE YIELD OF MAIZE (VARIETY KATAMBILI), PLANTED ON EIGHT DATES AT WEEKLY INTERVALS

(*Nachingwea*, 1954)

Date of planting	Days to harvest	Population/acre	Yield of seed, lb./acre	Shelling percentage	No. of cobs/plant	No. of seed/lb.	No. of seed/plant	No. of seed/cob	Bushel weight (lb.)
T/1 23 Dec.	105	8,336	2,625	81·3	1·44	1,448	456	317	61·1
T/2 30 Dec.	105	7,818	2,470	81·0	1·20	1,445	456	380	60·4
T/3 6 Jan.	104	7,870	1,600	79·0	1·16	1,760	358	309	58·2
T/4 13 Jan.	104	6,990	1,502	80·6	1·09	1,769	380	349	57·1
T/5 20 Jan.	100	8,232	1,605	79·7	0·96	1,866	364	379	57·9
T/6 27 Jan.	98	7,715	1,186	78·7	0·89	2,107	324	364	57·2
T/7 3 Feb.	97	7,456	859	78·3	0·85	2,466	284	334	55·6
T/8 10 Feb.	97	7,766	678	76·2	0·85	2,681	234	275	54·0
Mean	101	7,773	1,566	79·3	1·05	1,943	357	338	57·7

Taking the age of each planting when the rust index reached 3.0 a regression of yield with these comparative figures for rust incidence is evident. However, there is also a yield regression with the total amounts of rain falling on each planting, and as the correlation between the two regressions is high, it is not possible to separate them. The figures for these regressions are presented in Table 4.

TABLE 4.—REGRESSION OF YIELD WITH RUST INCIDENCE AND WITH AMOUNT OF RAIN FALLING AFTER PLANTING

	Yield of seed (lb./acre)	Age when Rust index =3 (days)	Rain falling after planting (in.)
T/1 ..	2,625	77	21·80
T/2 ..	2,470	76	20·09
T/3 ..	1,600	74	19·25
T/4 ..	1,502	73	18·60
T/5 ..	1,605	68	16·44
T/6 ..	1,186	64	16·09
T/7 ..	859	60	14·31
T/8 ..	678	57	13·87

SUMMARY

The incidence of *Puccinia polysora* rust on the maize crop has been studied at Nachingwea. It has been shown that the initial infection takes place at progressively earlier stages on later plantings, spreading from adjacent established epidemics, but once the initial infection has occurred, the rate of increase in any planting is uniform. Consequently the aim in any agronomic system of control lies in delaying the initial incidence on the crop: one appropriate method is the avoidance of small plantings in advance of the main crop.

The losses in yield due to the rust infection are heavy. They have been estimated by the use of a blanket fungicide treatment, and by the comparison of early- and late-planted plots. The lower yield is a result of a reduced number of cobs per plant, and a considerable reduction in the individual seed weight. The incidence of the rust has no effect on the carbohydrate/protein ratio in the seed.

ACKNOWLEDGMENTS

I am indebted to Dr. A. C. Evans for his direction of this study on behalf of the Overseas Food Corporation, and to Dr. H. H. Storey for his interest and the assistance of the E.A.A.F.R.O. Chemistry Department with the analyses for carbohydrate and protein.

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A NOTE ON GREEN-VEIN CHLOROSIS OF COFFEE

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The writer has frequently noticed a particular type of leaf symptom on mature coffee (*Coffea arabica*) which appears to be related to a temporary deficiency of available iron. Limited field observations indicate that this condition is not confined to coffee grown on red soils of volcanic origin in Kenya, i.e. Kikuyu Red Loam series, since the presence of a similar condition has been observed on mature coffee growing on soils of the Basement Complex.

The symptoms, termed by us "green-vein" chlorosis, are very striking, and are similar to those recorded for many other crops of wide variety, e.g. citrus, peach, runner beans, and attributed to a lack of available iron in the plant or tree. With coffee, the interveinal areas of the leaf, in cases of increasing severity, are progressively paler in colour and eventually yellow with, in the final stages, complete absence of chlorophyll. The veins of the leaf retain a healthy green colour throughout, though in very extreme cases the finer parts of the network become "bleached" in a similar manner.

Symptoms of this type have been produced and described by Franco and Mendes [1] working with coffee plants (*Coffea arabica*) grown in nutrient solution, and were reported to be the direct result of an iron deficiency.

Experimental

When the long rains (1953) season was over, diagnosis of green-vein chlorosis symptoms present on mature single stem coffee at the Coffee Research Station was commenced, using a leaf application technique. Costa and Franco [2] have described a modified virus transmission technique which they have adopted successfully for diagnosing iron deficiency symptoms in young coffee plants, *Coffea Dewevrei* De Wild. et Th. Durant var. *excelsa* Chev. (syn. *C. excelsa* Chev.), in nursery beds. A half-leaf application of the selected nutrient solution is made, followed by gentle scarification of the tough leaf cuticle with fine carborundum powder. Absorption of the applied solution into the leaf proved to be much quicker and produced more satisfactory results with this scarification when compared with straight half-leaf application.

Replicated applications were made of solutions containing trace elements, deficiencies of which might be considered the causative agent. Manganese, zinc, copper and iron sulphates were applied individually at a strength of 0.15 per cent w/v plus a 0.05 per cent v/v addition of a wetting agent (Teepol). Double-distilled water was applied as the control. Copper was included in the nutrients tested, not because of its connection with leaf chlorosis symptoms, but because of the recognized "greening-up" effect of copper tonic sprays in coffee, the mechanism of which is imperfectly understood [3].

Only the ferrous sulphate solution was effective, and half-leaf treatments with this solution showed varying degrees of recovery of the natural colour. The carborundum powder available at this time was rather coarse and some degree of mechanical damage occurred from the effects of too vigorous scarification with this material.

During and following the long rains 1954, green-vein chlorosis was again observed on some mature trees. A particularly large proportion of the leafage (estimated in some instances as 30–40 per cent), of a small group of trees situated below the irrigation water tank on the Rukera Demonstration Farm were affected with the typical symptoms. Leakage of water had maintained moist soil conditions prior to the long rains (hot, dry period, January–March) and the coffee trees had made considerable vegetative growth. In addition these trees also carried a fair crop, at the estimated rate of 4–5 cwts. clean coffee per acre.

Ferrous sulphate solution was applied to half leaves using the scarification technique. Three hundred grit powder (extra fine) carborundum was used and little mechanical damage occurred. At the same time, a "leaf dip" technique was tested. With this method the tip of the leaf is cut off and immersed in the solution which is contained in a small waxed paper envelope. The envelope is attached to the leaf by two paper clips. This technique has been applied to sugar cane leaves by the writer, with success in the British West Indies. The uptake and dispersion of the solution within the coffee leaf was checked, using an acid red fuchsin dye solution. After 24 hours' tip-immersion, the leaf was examined for uptake of the dye, and very satisfactory results were observed. When applying this technique one of a pair of leaves showing the symptoms was treated.

The strength of the ferrous sulphate solution was increased to 0.25 per cent w/v plus 0.1 per cent v/v of "Teepol" in double distilled water. This solution was acidified with a few drops of dilute sulphuric acid. Double distilled water plus 0.1 per cent v/v of "Teepol" was used as the control with both the treatment methods.

Applications were first made early in June and excellent results were obtained. (*See* Fig. 1.) Recovery of the full green-leaf colour was apparent in leaves treated with ferrous sulphate solution by both the methods described.

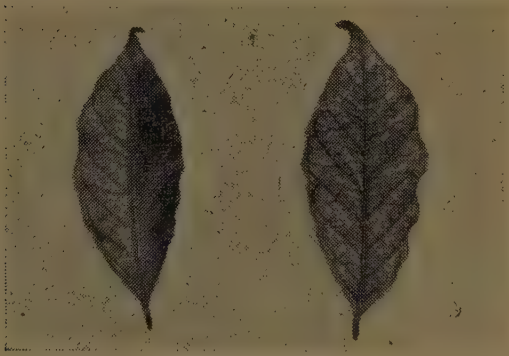

Fig. 1—An example of the leaves of Coffea arabica showing, on the right, typical symptoms of green-vein chlorosis and, on the left, the effect of a half-leaf application of ferrous sulphate solution.

In order to test the possibility of correcting this iron deficiency by a routine type of spray application, one leaf from each pair of affected leaves was sprayed with 0.25 per cent w/v ferrous sulphate solution, plus a 0.1 per cent Teepol addition, on both the lower and upper leaf surfaces. First fully open pairs of leaves on (*a*) young multi-stem primaries and (*b*) old single stem primaries and secondaries, were treated in this way. Four weeks after a single application, recovery of the normal green leaf-colour on the treated leaves of the young multi-stem primaries was complete. Recovery of leaves on the old single stem primaries and secondaries was not complete, but an increase of the green leaf-colour was noted in every case.

Discussion

It has not yet been possible to judge the economic importance of this condition in mature arabica coffee. Discussion with Mr. R. W. Rayner, Plant Pathologist/Physiologist, Coffee Services, has confirmed the opinion formed at present that the symptoms occur on young leafage produced at a time of rapid growth. Under natural climatic conditions the greatest incidence has been observed on young suckers which have produced very rapid growth during the long rains period, and on the leaves produced by mature coffee trees which carry little or no crop and which have produced a rapid and luxurious leafage. The writer has observed that later in the year, August-September, leaves exhibiting symptoms of green-vein chlorosis often occur behind the youngest pair of fully open green leaves, whilst the third and fourth pairs of mature leaves are also green and apparently healthy.

The condition appears to be related to the rate of iron availability to the tree, or parts of the tree, during periods of rapid vegetative growth. These naturally coincide with periods of available soil moisture and satisfactory atmospheric conditions, and it is reasonable to postulate that the former condition may influence the degree of iron availability to the tree, through effects on the mechanism of soil pH variation and the degree to which certain nutrients become available, possibly creating conditions antagonistic to the uptake of iron. Although no true parallel exists, it is interesting to note that Franco and Mendes [1] found in their nutrient solution growth studies that a certain combination of high available phosphorus and a pH higher that 5.5 restricted the absorption of iron from solution to such a degree that a deficiency occurred in the coffee plants.

If a mechanism similar to this does exert an adverse influence on the rapid uptake of iron, when soil moisture conditions are favourable and rapid vegetative growth is taking place, then the irrigation of coffee for increased production might be expected to effect an increase in the incidence, and perhaps the severity, of green-vein chlorosis. The problem would then become a truly economic one.

SUMMARY

1. A visual nutrient deficiency symptom which occurs in leaves of mature coffee (*Coffea arabica*) is described in detail.

2. This condition has been descriptively termed green-vein chlorosis.

3. Since green-vein chlorosis can be corrected by an application of 0.25 per cent w/v ferrous sulphate it is concluded that it arises from a deficiency of this micro-nutrient in the leaves during periods of rapid vegetative growth.

4. This investigation has not proceeded to a stage where it is possible to say that under natural climatic conditions the control of this deficiency would or would not have a beneficial effect on yield.

ACKNOWLEDGMENT

I wish to express my thanks to Mr. R. W. Rayner, Plant Pathologist/Physiologist (Coffee Services) for the technical assistance received in producing the photograph for figure 1.

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POPULATION AS A FACTOR IN LAND USAGE IN THE NYANZA PROVINCE OF KENYA COLONY

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(*Received for publcation on* 14*th August*, 1954)

The post-war era has witnessed a considerable expenditure of time, thought and energy upon the problems of the colonial peoples. This is true of the British East African territories, as elsewhere, but here perhaps the most useful single contribution made so far has been the enumerating of the African population in the 1948 census. An accurate knowledge of the distribution of the indigenous peoples is important to determining agricultural policy especially with regard to land usage. The 1948 census, undertaken by the East African Statistical Department, provides for the first time reasonably accurate information as to the extent and distribution of the native population of the East African territories. The information thus collected can be utilized in many ways, in association with evidence from other sources. The aim of this paper is to consider population as a factor in land usage in the limited region of the Nyanza Province of Kenya.

Earlier estimates of the native population of this province were based, as elsewhere in East Africa, upon the total number of taxpayers, a well-known figure, though far from being accurate. The estimating of the native population was subject to underestimation for two reasons. Firstly, the number of taxpayers was in itself an understatement due to difficulties experienced in the collection of tax. Secondly, the method employed to ascertain the total population from this inaccurate basic information was also defective. For it was assumed for the purpose of estimating the total population that the number of poll tax payers represented 49 per cent of the total adults; the remaining 51 per cent being the adult female population. In calculating the juvenile population it was further assumed that the children were 37 per cent of the total population. This was, however, a gross underestimation of the number of children in Nyanza. The cumulative defects in these early attempts to estimate the native population meant that the figures finally obtained were "certainly not accurate enough to justify the inclusion of more than three significant figures in the total of a million" [1].

None the less these figures do show a continued trend of an increasing population in the province, a natural outcome of improved health facilities and the cessation of tribal warfare since the coming of British government in this area. In 1928 the African population of Nyanza was estimated at 1,113,858 persons, and ten years later to have reached a total of 1,203,926 persons [2]. Allowing for the questionable nature of those estimates, it may perhaps be conceded that over a period of 20 years to 1948, when the census figures enumerated 1,853,232 Africans in the province, that there had been approximately a 50 per cent increase in the native population of Nyanza. The rapid increase in population and its continued growth to the present time has a tremendous relevance to the problems of an agrarian people, especially with regard to the availability of land, and its use to provide subsistence and cash crops.

The 1948 census provides a convenient moment-in-time analysis to examine the vital problem, in the Nyanza Province, of the density and distribution of the population. Such evidence has some relevance to the agrarian problem, though more fundamental to determining agricultural policy is a knowledge of utilizable acreage per family [3]. In North Nyanza there was at that date a population density variable from 131 per square mile in the Elgon Location to 1,000 per square mile in Bunyore. The minimum and maximum densities in Central Nyanza were 71 in Kadimu (Yimbo) and 569 in Kajulu respectively, whereas in South Nyanza there was a minimum of 24 per square mile in Kaksingiri and a maximum of 500 in Majoge; and in the native locations of the Kericho District there was only a slight difference in density between 124 per square mile in Location VI and 153 per square mile in Location III.

Table I has been prepared from the figures for the 1948 African population as given in *Geographical and Tribal Studies*: *Kenya Colony*, 1950 [4]; and the density calculated on the basis of locational areas given in *Appendix "E" of the Annual Report of the Provincial Commissioner, Nyanza Province*, 1948. This table shows the geographical distribution of the African population according to density per square mile in graduations of

50 persons per square mile. Though there were slight divergences between the districts comprising the province, it will be seen that 64.1 per cent of the entire province was populated in 1948 at a density between 100 and 249 persons per square mile.

A moment-in-time analysis of population density in the case of the indigenous peoples of Nyanza is deficient in two ways. Firstly, the obvious limitation of a moment-in-time analysis when there is a continued growth of the population. Secondly, a census assessment is further deficient when additional to the continued movement of the natural increase of the population there is also a migratory movement of population, mainly of adult males engaged in work away from their homes and returning there after a period of absence which varies in each particular case. None the less the 1948 census does provide a photographic exposure of the nature of this problem at a moment-in-time. For at that date, in the case of the four main tribes of the Nyanza Province [5] there were 101,926 males and 45,414 females living outside the province. This represented respectively 13.7 per cent and 5.8 per cent of the total numbers of these tribes as enumerated in 1948, in respect of the African population of Kenya Colony. In the labour census of the same year (November) it was estimated that some 125,000 Nyanza males were in employment, some of them for employers within the province, others elsewhere in the Colony. The absence of so many male members has led Professor Frankel to consider this a major handicap in the advancement of the agrarian production of the province [6].

Unfortunately, at present, there is no reliable method of calculating the length of time these adult workers are absent from their home, other than by samples which might be revealed in the course of a village survey and census undertaken over a period of time, with constant observation, such as an anthropologist might undertake. It is, of course, possible to exaggerate the significance of this absenteeism of the adult male worker in relation to land availability and usage. It does not follow that upon return to his village that the man will demand a share of the land, for if he is already married (as many are) he will already possess his *shamba*, which will have been in cultivation during his absence. This factor of labour-migration merely qualifies for density purposes the validity of a moment-in-time analysis.

The return of the male does of course mean an additional demand upon the subsistence crop of the locality, and when the contribution of the Nyanza natives to the economy of the Colony and of East Africa in the export of surplus food crops (as well as cash crops) is considered, any incursion upon the available surplus food in particular has more than a local significance. But here the major problem is not the return of the migrant labourer, but rather the consequences of natural increase which, as already pointed out, despite the deficiencies of earlier estimates, has been in the region of a 50 per cent increase in the period 1928–1948. So far, especially has this been true of North Nyanza, it has been possible not only to maintain the local population, but to stave off starvation in other parts of East Africa, and indeed at times in the less fortunate areas of the province itself. There are, of course, obvious ill effects from this constant maize-mining, and the deterioration of the quality of the land is of vital importance to the future economy of East Africa, that is, whether or not in the years to come the indigenous peoples of Nyanza will be able to continue to export surplus food crops. But equally important in answering this question is the unknown factor as to the extent to which the native population of the province will increase. Lack of information as to the birth-rate or even of the fertility of the females of Nyanza handicaps any accurate estimation of the trend of increase. That there will be a continued increase is certain from only a cursory knowledge of the African attitude towards the establishment of a family and with the statistical knowledge of the 1948 census that 57.7 per cent of the adult African population of the Nyanza Province were females.

Although the immediate consequence of an increasing population is that of "more mouths to feed" there is a second delayed consequence which arises and only becomes operative after a number of years. And that is the necessity under the present indigenous attitude towards land, of providing land for occupation and cultivation when males reach the age of marriage and have to provide *shambas* for their womenfolk. The danger of over-population thus becomes acute, and there is the accompanying resort to fragmentation of land-occupation. The density distribution of the Nyanza Province, as already discussed, gave some indication of the problem, though other factors such as utilizable acreage per family

TABLE I.—GEOGRAPHICAL COMPOSITION OF THE AFRICAN POPULATION OF THE NYANZA PROVINCE, 1948, ACCORDING TO DENSITY DISTRIBUTION PER SQUARE MILE

DENSITY Persons per Square Mile	NORTH NYANZA			CENTRAL NYANZA			SOUTH NYANZA			KERICHO			NYANZA PROV.	
	No. of Locations	Total Sq. Miles	per cent of District	No. of Locations	Total Sq. Miles	per cent of District	No. of Locations	Total Sq. Miles	per cent of District	No. of Locations	Total Sq. Miles	per cent of District	Total Sq. Miles	per cent of Province
0– 49							2	218	7·3				218	1·8
50– 99				1	100	5·7	3	634	21·1				734	6·7
100– 149	2	396	16·2	1	162	9·3	6	625	20·8	4	603	61·0	1,786	26·8
150– 199	5	616	25·2	1	99	5·6	2	229	7·6	2	386	39·0	1,330	19·4
200– 249	4	561	22·9	2	361	20·6	7	848	28·3				1,770	17·9
250– 299	3	361	14·8	2	354	20·4	1	18	0·6				733	8·9
300– 349	1	34	1·4	5	549	31·4	1	55	1·8				638	8·7
350– 399				1	23	1·4	2	168	5·6				191	1·8
400– 449				1	84	4·8	1	155	5·2				239	2·5
450– 499														
500– 549	2	107	4·4				1	52	1·7				159	1·5
550– 599				1	14	0·8							14	0·2
600– 649	1	200	8·2										200	2·1
650– 699	1	27	1·1										27	0·3
700– 749														
750– 799	1	95	3·9										95	0·9
800– 849														
850– 899														
900– 949														
950– 999														
1,000–1,049	1	45	1·9										45	0·5
	21	2,442	100·0	15	1,746	100·0	26	3,002	100·0	6	989	100·0	8,179	100·0

and the quality of the soil are complementary factors.

The selection of the Nyanza Province for some observations of land usage in relation to the population information of the 1948 census has more than a regional base for its choice, in view of its contribution to the economy of the Colony and East Africa in general, particularly in the supply of surplus foodstuffs. The incompleteness of the available data does not facilitate the formulation of any definite conclusions; but it is suggested that a knowledge of the distribution, density and growth of the African population are essential to an understanding of the agrarian problem, including land tenure; and must be borne in mind when determining future agricultural policy.

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SMALL PATCHES WITH PERMANENT RED LOCUST POPULATION IN NORTHERN TANGANYIKA TERRITORY

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(*Received for publication on 11th August*, 1954)

The area covered by Red Locusts (*Nomadacris septemfasciata* Serv.) during the outbreak years 1927–1945 comprised among others the whole of Tanganyika Territory (Morant, 1947). Michelmore (1936) who made extensive traverses of Tanganyika Territory, gives detailed descriptions of the distribution of Red Locusts at that time.

Although Michelmore himself states that the colour of locusts may change during their adult life, at least under the influence of environment, he tries to distinguish between solitary locusts and stragglers from swarms on the basis of coloration only. However, with our present knowledge, it is impossible to use the colour of adult Red Locusts as a phase character. Michelmore found what he defines as solitary Red Locusts practically everywhere in open, or more or less open, grasslands with tussocks of grass one foot high or taller. At the same time he found stragglers from swarms in most of the same areas. At present the solitary Red Locust is rare in Tanganyika Territory, except in Rukwa, Malagarasi, and Wembere. Finds of single specimens, although difficult to explain, are not really unexpected anywhere, but constant small populations are few and little known. The general presence of solitary Red Locusts in 1935–36 as contrasted with the extreme scarcity in recent years may be explained in two ways: (*a*) a general increase of Red Locusts during outbreak years, not only of phase *gregaria* and phase *transiens* but also of phase *solitaria*, not only in the outbreak areas, but all over the territory. (*b*) The Red Locusts recorded by Michelmore were not true *solitaria* bred *in situ*, but stragglers, possibly stragglers of a second or later generation.

The annual increase in the area infested by Red Locusts during the last plague was studied in as much detail as possible. The decrease of the same area after the outbreak years has not been followed in the same way. Yet it may be of equal interest for a true understanding of the ecological differences between infested grass, survival areas, and outbreak areas. The fact that single specimens of Red Locusts may even now be found in places where there is no permanent population makes an ordinary distribution map valueless. Only habitats with permanent populations, and the distribution of these habitats, should be considered and compared to the outbreak areas.

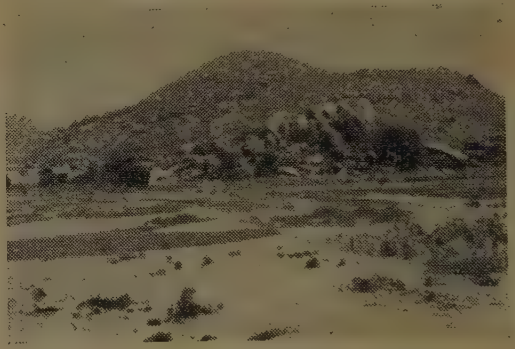

Fig. 1—Overgrazed grasslands in Tinde; in the background are hills which give rise to small streams with Phragmites.

Mossop (1951) published a paper about a restricted population of Red Locusts in the vicinity of Fort Victoria, Southern Rhodesia. The locusts were only found in close proximity to irrigation channels, not on cultivated land, but in patches of "weeds". The vegetation had a mixed character with many species of tall and short grasses as well as herbs. As far as can be seen from the short description I should imagine that such vegetation would have the character of a mosaic if it covered a larger area. Mossop says, "In limited areas, nevertheless, numerous adults of *N. 7-fasciata* were present in circumstances which suggested a small measure of gregariousness". In a footnote, measurements of eleven males and five females are described. "M. Bredo (of the International Red Locust Control Service) considers that, as far as these few figures reflect the position, the locusts are of the phase *solitaria.*" Morphological phase, determined on an inadequate number of specimens, is here compared to density of populations, not to behaviour or ecological phase. "Phase" in such a case is as artificial as "phase" in cage-bred locusts.

Dr. E. Burtt of the E.A. Tsetse Research Organization informed Dr. Uvarov of the Anti-Locust Research Centre in London that he could obtain a limited number of specimens of Red Locusts in Shinyanga during any year. Acting on this information I visited Northern Tanganyika Territory in August, 1951, and found several small but dense populations of Red Locusts in several places. Without the help of Dr. Burtt I would not have found these populations, as the habitats are entirely different from those of the Red Locust in the outbreak areas. However, these habitats have some characters in common with that described by Mossop (1951).

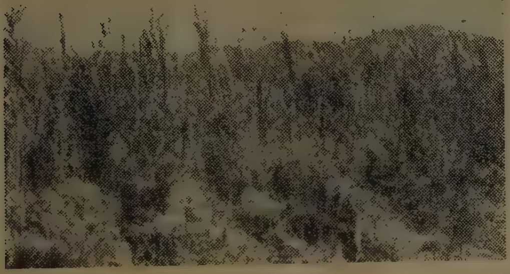

Fig. 2—Habitat. of Red Locust. Cynodon dactylon, Phragmites, Hyparrhenia, Asclepias.

Red Locust habitats in Shinyanga

The southern part of Shinyanga district is mainly a very flat plain. At Tinde, and in some other places, the plain is interrupted by boulder-strewn, weathered-granite hills. The plain is a cultivation steppe dotted with *Adansonia* trees. The cultivation is shifting and occupies only a small fraction of the plains and most of it is overgrazed to such an extent that 50–90 per cent of the soil is bare in August. This is the kind of country which does not support a Red Locust population even in outbreak years. Flooding is intensive but ephemeral. The soil of this seasonally-flooded plain is a black clay, covered in many places by a thin layer of sand, with horizons of sand and gravel washed out from the hills. Numerous deep river courses, completely dry most of the year, traverse the country. The hills give rise to small permanent brooks in narrow channels which dry up within a distance of a mile from the base of the hills. In their natural state these rivulets were undoubtedly fringed by trees and some few *Phœnix* palms persist. Now these brooks are utilized for irrigating a narrow strip of land where rice and maize are grown. Even within the irrigated strip there is, however, shifting cultivation only. Uncultivated soil is invaded by grass and herbs within a few months. *Phragmites* is one of the dominants in all these localities. *Phragmites* is not a climax species here, but it is a fast invader. With its hard and pointed leaves it withstands grazing by cattle and even by sheep and goats.

The patches of *Phragmites*-dominated vegetation are rarely more than 600 × 200 metres and they are not numerous. The local guide knew only of ten such patches in Tinde. The average distance between the localities is more than a mile. Each such patch is visible from a distance as the only green tall-grass feature of the landscape. As an example one of these patches will be described in detail.

The whole irrigation area is 600 × 100 to 220 metres. The irrigation has been accomplished not so much by channels as by building a series of dams with stagnant water in rectangular areas 20 × 20 to 60 metres. The dam surrounding the whole area is 1 metre high and 1½ metres wide and the dams between the small plots are much lower. This particular irrigated area was not all in cultivation in 1951. In the plots nearest to the brook there was still stagnant water in August, or the soil was wet. In this wet part the vegetation was low; on the dams there was close-grazed *Cynodon dactylon, Juncus* sp., various herbs and *Lemna.* The tall grass occupied the moist but unflooded part of the area, approximately 300 × 50 metres. It consisted of three regions: (*a*) A native garden cultivated during 1950–51 with some few remaining maize culms. The vegetation was open, dominated by invading *Phragmites* and *Vinca,* the latter from a nearby garden. In hoed furrows there was an undergrowth of *Cynodon* and some few herbs. (*b*) Older native gardens with closed vegetation and almost obliterated furrows. In some places there was some stagnant water. The vegetation was dominated by *Hyparrhenia* (?) *rufa,* seconded by *Phragmites.* An *Asclepiad* was also characteristic of the upper layer. In the bottom layer *Cynodon dactylon Conyza, Sonchus,* and other herbs made an incomplete cover. (*c*) In the main dam, the vegetation was closed and resembled that of the older native garden but *Phragmites* dominated over *Hyparrhenia.*

For this whole area I estimated a population of approximately 30 Red Locusts. At least between 9 and 11 a.m., they were all concentrated in the tall vegetation. The locusts were difficult to catch, but although the sun was high, they rarely flew more than 10–20 metres. This type of behaviour was also noted by Mossop (1951), and may be correlated with the small size of the habitat. I did not see a single locust leave the tall vegetation; they moved back and forth in *Phragmites*. After the scouts had traversed the area several times no locusts were flushed any more. This need not mean that they had left the area; they were certainly hiding among the bases of the grass.

In the tall grass *Cyrtacanthacris tatarica* was approximately twice as numerous as *Nomadacris septemfasciata* and the following grasshoppers were also found: *Mesopsis* sp., *Paracinema* sp., *Ornithacris cyanea, Acanthoxya* sp., *Catantops saucius, Tylotropidius specious,* and *Tylotropidius* sp. In the low-grass vegetation *Aiolopus* sp. was dominant, followed by *Paracinema* sp., *Morphacris* sp., and *Acrida* sp.

Other localities with Red Locusts in Tinde had a very similar vegetation and grasshopper fauna, even where part of the irrigation area was actually used as a rice field. Among other plants noted *Chloris gayana, Sesbania* sp., and *Corchorus* sp. may be mentioned.

In Old Shinyanga there is at least one locality with Red Locusts that is very similar to those in Tinde. It is not, however, associated with irrigation fields. A Phragmitetum grows here around a sluggish, semi-permanent river at the bottom of a shallow valley.

Red Locust habitats in Maswa District

Southern Maswa District is even flatter than Shinyanga District, and no granite outcrops break the monotony of the plains. Numerous river beds traverse the country. Although the river beds are dry during the greater part of the year, ground water can be found in the sand of the rivers. In most parts the river banks have the same overgrazed annual grass vegetation as the remainder of the country, but in some few places they are covered with stands of *Phragmites.*

A Phragmitetum in Mpalagane was 10–15 metres wide and 500 metres long. The soil was a black clay, mixed with fine sand. The soil had once been hoed; it was an abandoned native garden. The vegetation was dominated by *Phragmites,* in most of the area sparse and less than 2 metres tall. Interspersed among the *Phragmites* was some *Hyparrhenia.* In the undergrowth *Cynodon dactylon* was dominant, but not forming a complete cover. The soil surface was dry and hard (26.VIII. 1951) but since the *Cynodon* was green there was certainly some moisture not far below the surface. Some 20 *Nomadacris* were flushed in this area together with *Cyrtacanthacris, Acrida,* and *Eupreprocnemis.* In the surrounding overgrazed area *Morphacris* sp. and *Pycnodictya* sp. were numerous.

In Lalago a similar locality was studied. Here it was even drier: *Phragmites* was sparse and to some extent grazed. There was no *Hyparrhenia,* but some few dry stalks of *Hibiscus* and *Corchorus.* The undergrowth consisted of *Cynodon dactylon,* dry and grazed. Although this *Phragmites* stand had almost the same extent as the one in Mpalagane, only one *Nomadacris* and one *Cyrtacanthacris* were flushed.

Several other stands of *Phragmites* were seen from the road through field-glasses. Undoubtedly some of them at least, are habitats of Red Locusts.

Discussion

The Red Locust habitats described in this paper are in most respects very different from those in the outbreak areas. One feature in common is the presence of tall grass in a non-uniform, not too dense stand. Another feature is the presence of green grass throughout the year.

Mossop (1951) regards the patch of Red Locusts in Fort Victoria, Southern Rhodesia, as persisting since the latest big locust plague. In the case of the Tinde populations we have the direct evidence of Dr. Burtt (*in lit.*) that they are permanent. Also, natives have informed me that they know the hoppers to live exclusively in these patches: the hoppers are said to feed on *Hyparrhenia,* not on *Phragmites.* Whether these populations should be regarded as survivors from the latest outbreak, or whether the populations are older, is an academic question which cannot be answered at present. All the habitats are anyhow a result of native shifting cultivation and are thus not very ancient.

This paper is an abstract from a fuller unpublished report in the library of the International Red Locust Control Service, Abercorn.

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RECOMMENDATIONS BY THE INTERNATIONAL FEDERATION OF AGRICULTURAL PRODUCERS

The following is the text of the I.F.A.P. Policy Committee recommendations which were passed at the Seventh General Conference in Nairobi, Kenya, May, 1954.

(Extracted from *World Farm News*, June–July, 1954)

"The Committee makes the following recommendations on points of substance:—

(*a*) The Committee feels that the most immediate problem confronting agricultural producers at the present time concerns the disposal of present heavy surpluses of certain commodities of great importance in world trade and in this regard recommends—

(i) that governments of the countries possessing unwieldy surpluses consider and put into effect programs designed to bring about a shift in production away from the production of crops and livestock products now in surplus in these countries and towards the production of products in greater demand in their home markets.

(ii) that governments of the countries possessing the surpluses take steps to facilitate the disposal of surplus stocks in their own domestic markets (e.g. by improving marketing efficiency, special welfare programs, special feeding programs for certain vulnerable groups, etc.).

(iii) that intergovernmentally agreed rules be adopted by the countries concerned regarding principles to be followed in the disposal of surplus stocks in the world markets so that they interfere as little as possible with normal production and trade, and that effective intergovernmental machinery be established for consultative purposes. In this connexion the Committee commends the initiative taken by the FAO through its Working Party on Surplus Disposal and trusts that strong and effective consultative machinery will be established as a result of the Working Party's recommendations. The Committee realizes that there will be considerable practical difficulty in formulating principles but the following is suggested for the consideration of governments:

1. Since any sale of surpluses must have some impact on prices and on the trading interests of third countries, it is essential that special disposal schemes should be directed towards attaining a net addition to consumption.
2. It is desirable that the intergovernmental machinery should in general give priority to schemes for disposal of surpluses in the underdeveloped countries where in turn their receipt should be linked to, and carefully synchronized with, schemes for general economic development.

(iv) with regard to governmental programs which involve sales abroad of a product at less than the domestic price, the Committee feels that, while these may be inevitable for certain commodities in present circumstances, every effort should be made to use the consultative machinery referred to in (iii) above in respect of any new programs in order to avoid damage to the interests of friendly countries.

(v) that the governments of countries normally deficient in respect of the surplus products in question avoid the adoption of measures designed to restrict the importation of needed supplies of these products.

Correcting Unbalance of Production and Consumption

(*b*) The Committee feels that the problem of correcting the present unbalance between the world's capacity to produce agricultural products and the world's capacity to consume them is of even greater importance than the current problem of surplus disposal, and in this respect recommends:

(i) that emphasis be placed by governments on measures designed to expand consumption rather than on measures designed to restrict production. The world needs more food and fibre, rather than less, if the world's people are to be adequately fed and clothed.

(ii) that governments of the more developed, industrialized countries should have readily at hand programs and policies designed to assist the shift in production from the goods of war to the goods of peace in the event, as must be fervently hoped, the world should turn to more peaceful ways.

(iii) that, in respect to the countries in the process of development, increased emphasis should be given to technical assistance from the more developed countries. In this regard it is urged that larger funds be made available to international agencies, such as FAO, for the conduct of this work.

(iv) that every effort be made to increase the amount of capital from both foreign and domestic sources, available to under-developed countries, without which technical assistance is largely to no avail. The Committee feels that such capital should come as largely as possible from private sources but that in its absence, funds for development should be provided through governmental or intergovernmental agencies. The Committee urges that everything possible be done to induce governments of countries short of capital for use in economic development, to make the conditions (in matters of taxation, currency convertibility, remission of profits and so forth) more attractive to investment by those possessing surplus capital in the more developed countries.

Intergovernmental Consultation

(*c*) The Committee realizes that the road between the present period of surpluses and the achievement of a reasonable balance between the capacity to produce agricultural products and the capacity to consume them may be long and that it will not be easy. It realizes also that national governments, during this transition, will continue to protect the interests of their own producers, through price support measures and otherwise. It is convinced that uncoordinated national measures have contributed and are likely to continue to contribue to the accumulation of excessive stocks and to instability in world market prices. It feels, therefore, that effective intergovernmental co-operation during this transitional period is urgently required, and accordingly recommends:

(i) that, in the long run, the basic solution to the present unbalanced situation in the world agricultural economy must be found in a progressive reduction in the barriers to world trade, including the full convertibility of national currencies.

(ii) that IFAP reaffirm its faith in intergovernmental commodity agreements as a means of bringing about greater stability in the prices of major commodities moving in world commerce and assist in creating a better public understanding of the underlying philosophy of such agreements as an important means of stabilizing trade.

(iii) that in this connexion the possibilities of bringing about a more satisfactory operation of the International Wheat Agreement be actively explored by the governments concerned and by international agencies.

(iv) that, in respect to problems of largely regional interest, governments consider the feasibility of regional agreements or arrangements with regard to agricultural production, distribution and prices.

(v) that a conference sponsored by IFAP should be held as early as possible between representatives selected by IFAP member organizations in the interested IFAP dairy exporting and importing countries to consider what steps can be taken to achieve an improved and orderly flow of trade in dairy products."

INSECTICIDES AND COLONIAL AGRICULTURAL DEVELOPMENT*

There has recently appeared volume six of the "Colston Papers", under the title that heads this note. These Papers are records of annual symposia organized by the Colston Research Society of Bristol University; past symposia have ranged over diverse subjects, from Colonial administration to cosmic rays. The present volume provides a valuable record of developments in insecticide research and their application to Colonial agriculture.

Sixteen papers were presented at the Symposium and are printed in full together with records of the discussions. Many deal with specific problems of insect control on plants and animals, all of wide interest to the agriculturist; and four describe work done in East Africa on cotton, clove, coconut and a variety of field crops. Finally, when the biologists had had their say, an engineer contributed a valuable paper on spraying technique and machinery and a chemist one on the insecticide manufacturer's research and supply problems.

Some attempts were made to assess the crop losses that could be attributed to insect attack. In his Preface, T. Wallace put these losses, very tentatively, as of the order of one hundred million pounds for the Colonies as a whole, against actual exports in 1949 of £182–183 millions. W. J. Hall, in his general survey, quoted some specific instances. In one of the Fiji islands the introduction of an effective parasite of the Coconut Moth, involving the expenditure of £22,000 on research and development, had saved a crop worth to-day annually some £2½ million. The spraying of cotton in the Gezira against jassid, at a cost of £200,000, had produced in 1949–50 an increase of yield estimated to be worth between £4 and £5 million. Uvaroff is quoted as estimating the annual loss due to locusts and grasshoppers throughout the world at some £15 million, and possibly twice this sum.

Although their authors present these figures with all reserve, since many factors difficult to assess enter the estimation of crop losses, yet the figures are imposing enough to indicate the magnitude of the problem of crop protection in the Colonies and to justify the Colston Society in choosing this subject for their 1953 Symposium.

It is interesting to note that the specialists' papers tend on the whole to deal with general problems of insect control rather than directly with the use of insecticides. An exception is Callaway's paper on locusts, to the control of which there is scarcely any approach except through chemical poisoning; and also two papers, by Carmichæl and Harbour, on insect vectors of animal diseases. Swaine alone among the entomologists concerned with insects of crop plants devotes his paper mainly to descriptions of experiments in control by insecticides. He is able to produce imposing evidence; for instance, a yield of 1,483 lb. of seed cotton per acre when American boll-worm was controlled by a D.D.T./B.H.C. mixture, as against 13 lb. only from untreated plots.

Throughout the agricultural papers there is emphasis on difficulties and dangers. Difficulties arise over the design and interpretation of experiments. Thus McKinlay devotes his paper to discussion of the design in experiments with cotton; where a mobile insect like *Lygus* is to be controlled, small plots cannot be used for testing the efficacy of an insecticide, since the insect population rapidly redistributes itself over treated and untreated plots. Furthermore, McKinlay found that effective control of the pest might fail to enhance yield; a compensating mechanism in the plant might allow it to replace fruiting points killed by *Lygus* and to bring these to maturity if the infestation was not prolonged.

There is much emphasis on the practical difficulties of introducing insecticides into peasant agriculture, where crops may be grown on very small scattered plots.

Agricultural entomologists have generally been cautious in their attitude to insecticides and have recognized the dangers that may follow from upsetting the natural balance of insect populations. These dangers are emphasized in a striking article by M. J. Way, based on his work in Zanzibar. He deals particularly with the *Maji-moto* ant, *Œcophylla longinoda*, and its relation with a Coreid bug which damages young coconut fruits and seriously reduces the yield. The ant was a highly efficient controlling agent for the bug; so much so, that the presence of the ant largely decided whether the palm would yield a normal crop or practically no crop at all. When the ant population was destroyed with an insecticide the yield from certain experimental palms fell rapidly from an average of about four mature nuts on each successive spadix to nil. In conclusion, Way emphasizes "the danger of a short-sighted outlook on insecticide research where only the pest is studied and no account is taken of the general effect of an insecticidal treatment".

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* *Insecticides and Colonial Agricultural Development*, edited by T. Wallace and J. T. Martin. Proceedings of the Sixth Symposium of the Colston Research Society, Bristol, 1953. Published by Butterworths Scientific Publications, London, 1954, price thirty shillings.

REVIEW

METHODS OF SURVEYING AND MEASURING VEGETATION, by Dorothy Brown. Bulletin No. 42, Commonwealth Bureau of Pastures and Field Crops. Published by the Commonwealth Agricultural Bureaux, Farnham Royal, Bucks., England, 1954, price thirty-five shillings.

This publication contains such a mass of information that any attempt to review it in detail would inevitably require an extensive article. Miss Brown has, in fact, met a long-felt want in that she has collected together the world's methods for measuring the productivity of grassland and grazing areas, but has left it to the experimentalist to decide which procedures are the more appropriate to his particular wants and the type of herbage being studied. The variation between experimental requirements amply justifies this approach, but, with its classification of procedures and its descriptions of the relevant techniques, this bulletin is indeed "something approaching a grammar of methods", to quote the Introduction.

After opening with descriptions of open and dense grasslands with and without shrub growth, followed by a chapter on the theory of sampling by G. M. Jolly, the author considers the apparatus of sampling and the criteria of analysis. Chapters are devoted to recording vegetative frequency, the numbers of individual plants and the techniques for charting herbage. This is followed by a consideration of sampling by herbage weight and of the methods for determining yield and grazing capacity. The use of animals for measuring herbage yield is reviewed together with the relationships which exist between estimates of herbage and of animal productivity. The effects of the intensity of utilization are considered in relation to the productivity and persistency of the herbage, together with the value of weight or linear measurements for measuring utilization. The last chapter is devoted to the reconnaissance of range conditions to prevent over-grazing and the consequent deterioration of the herbage.

This summary of the subjects indicates the great value of such a compendium of information as a review of the past 20 to 30 years' work on quantitative grassland ecological studies. It can, therefore, be recommended as a reference work to research workers concerned with these problems. Its 14 pages of references will be of considerable help when deciding on the methods to be employed in a given environment and for a given purpose. Botanical analyses have been presented first, followed by considerations of productivity and utilization of the herbage, and this separation is an advantage because the botanist is concerned with a different aspect of the problem from the nutritionist. Each worker can readily group the problems confronting the other and this mutual understanding must lead to greater co-operation and a fuller investigation of the whole problem of grassland management and utilization.

M.H.F.

NOTES ON EAST AFRICAN APHIDS

VII—GRASS AND CEREAL STEM- AND LEAF-FEEDING SPECIES

By V. F. Eastop, East African Agriculture and Forestry Research Organization

(*Received for publication on 28th September, 1954*)

There are several very similar species of *Macrosiphum* (*Sitobion*) in East Africa resembling the European *M.* (*S.*) *fragariæ* (Walker), which, since they differ only slightly in such characters as the shape of the rostrum and the length of the body hairs, should be submitted to a specialist for identification. Microscope preparations resemble *M.* (*S.*) *nigrinectaria*, figured in Part III of this series. They may be black, blue, brownish, yellow or green in life. *M.* (*S.*) *avenæ* (*Fabr.*) (*granarium* Kirby, of some authors), only once recorded from East Africa (perhaps a misidentification), differs from the *fragariæ* group in that the siphunculi are only about one and one-quarter times as long as the cauda. *M.* (*Sitobion*) *sijui* Eastop, known only from Kenya where it feeds on *Cenchrus* and *Setaria*, differs from other *Macrosiphum* in the much shorter siphunculi (Fig. E), the apices of which bear only a few rows of hexagonal reticulation; and the shorter antennæ (Fig. D), the third segment of which does not bear rhinaria. *Metopolophium dirhodum* (Walker), known in Kenya only from *Bromus catharticus*, also occurs on cereals in Europe, but this may be a distinct sub-species. *Metopolophium* differs from *Macrosiphum* in that the siphunculi are not reticulated at the apex. *Metopolophium festucæ* (Theobald), not known from East Africa but important in Europe on cereals, differs from *dirhodum* in having evenly pigmented antennæ, gradually darker from base to apex, whereas in *dirhodum* the base of the sixth antennal segment is paler than the apex of the fifth; siphunculi three to four and one-half times as long as the second segment of the hind tarsi and one and one-half to twice as long as the cauda which bears five to eight hairs. In *dirhodum*, the siphunculi are two and one-half to three and one-quarter times as long as the second segment of the hind tarsus and one and one-fifth to one and three-quarter times as long as the cauda which bears seven to twelve hairs. The winged forms differ in that *festucæ* has a dorsel abdominal pattern of transverse black bars, while the dorsum of *dirhodum* is uniformly pale.

All other aphids feeding on the aerial parts of grasses in East Africa belong to the sub-tribe *Rhopalosiphina* which resembles the *Aphidina* but differs in that the lateral tubercles of the seventh abdominal segment (T) are placed dorsally or posteriorly (on the row of crosses in Fig. A) to the spiracle (S). In the *Aphidina* the tubercle is placed ventrally to the spiracle. Most *Rhopalosiphina* feed only on grasses and sedges, while the *Aphidina* are usually found on Dicotyledons. The *Rhopalosiphina* may be separated by means of the following key to the wingless adults. Both aerial and root-feeding species are included, as are a few species not known from East Africa but important elsewhere. A short key for the identification of the winged forms is also given.

KEY TO THE APTERÆ OF THE RHOPALOSIPHINA

The following abbreviations have been used:—a.s., antennal segment; C., cauda; h.t.2., second segment of hind tarsus (without claws); l.a.t., lateral abdominal tubercles; p.t., processus terminalis; S., siphunculi; u.r.s., ultimate rostral segment.

1 (6). S. small, little if any longer than broad, not more than one-quarter as long as c., less than one-thirtieth as long as body. P.t. one and one-quarter to one and three-quarter times as long as base of last a.s. C. with five or six hairs. Eighth tergite with four to ten hairs. L.a.t. absent. Mealy wax-covered aphids rolling the leaves of their host plants. Not known from East Africa.
Holcaphis Hille Ris Lambers.

2 (3). Eighth tergite with a mid-dorsal hair-bearing supra-caudal process, which is at least one-sixth as long as the cauda. **Cavahyalopterus** Mimeur.

3 (2). Eighth tergite without a tubercle.
Holcaphis sensu stricta.

H. holci (Hardy) and *H. frequens* (Walker) occur in Europe and *H. tritici* (Gillette) in North America.

4 (5). Supra-caudal process about one-quarter as long as c. or less. Central and Western Europe.
H.(C.) mühlei (Börner).

5 (4). Supra-caudal process about one-half as long as c. North Africa and Russia. **H.(C.) noxius** (Mordvilko).

6 (1). S. longer than broad, at least one-third as long as c. and one-thirthieth as long as body. P.t. more than one and three-quarter times as long as base of last a.s.

7 (8). S. only one-third to two-thirds as long as c. and only one-sixteenth to one-twenty-fifth as long as the body. Antennæ six-segmented, p.t. three to three and three-quarter times as long as base of six a.s. and four-fifths to equal in length to three a.s. which is three and one-quarter to four and one-half times as long as s. U.r.s. one-half to two-thirds as long as h.t.2. Eighth tergite with only two hairs, c. with only five hairs. A mealy wax-covered aphid not rolling the leaves of grasses. In East Africa known only from Muguga, near Kikuyu.

Hyalopterus pruni (Geoffroy).

8 (7). S. three-fifths to three times as long as c., one-fifth to one-seventeenth as long as body. If s. shorter than c. and less than one-tenth as long as body and p.t. more than two and one-half times as long as base of last a.s., then c. bears ten to twenty hairs.

9 (10). S. shorter than c., which bears ten to twenty hairs, s./c. ratio 0.6 to 0.9. Body one and two-fifths to two and one-third times as long as antennæ. U.r.s. four-fifths to eleven-twelfths as long as h.t.2. P.t. three to four and one-half times as long as base of last a.s. Antennæ usually six-segmented, if so, then p.t. one and one-half to two and one-quarter times as long as three a.s., which is only four-fifths to one and two-fifth times as long as the cauda; when five-segmented p.t. nine-tenths to one and two-fifth times as long as three a.s., which is two to two and three-quarter times as long as c. A white or yellowish ahpid in life, often with a dorsal abdominal broken black patch (Fig. M), which, however, may be absent. Common all over East Africa, particularly on *Sorghum*.

Longiunguis sacchari (Zehntner).

10 (9). S. longer than c. which bears only four to six hairs. If u.r.s. shorter than h.t.2., then p.t. less than one and three-fifth times as long as three a.s. Green or brown in life, never with a dorsal black patch.

11 (12). U.r.s. only two-thirds to five-sixths as long as h.t.2. P.t. two and one-half to three and one-half times as long as base six a.s. and not more than one and one-half times as long as three a.s. Body one and one-half to two times as long as antennæ, five and three-quarters to seven and one-half times as long as s. which are one and one-tenth to one and one-half times as long as c. Hairs on three a.s. eight to ten micro-mm., on hind tibiæ and eighth tergite not more than 35 micro-mm. A green aphid occurring on wheat and several grasses in Kenya. (Figs. N and O.)

Schizaphis graminum (Rondani).

12 (11). U.r.s. usually longer than h.t.2., if shorter, then p.t. less than two and one-half times as long as base of last a.s. and body nine to fourteen times as long as s., or p.t. three and three-quarters to five times as long as base six a.s., s. more than one and one-half times as long as c. and insect brown.

13 (14). L.a.t. absent. Eighth tergite with six to eight hairs. C. short, little longer than broad. Antennæ five-segmented, three a.s. more than two and one-half times as long as four a.s. P.t. three to four and one-half times as long as base five a.s., only one-half to three-quarters as long as three a.s. U.r.s. one and one-half to two times as long as h.t.2. On grass roots, Uganda and Southern Province of Tanganyika. (Part VI, Figs. O–R.)

Yezabura rhodesiensis (Hall).

14 (13). L.a.t. present on first and seventh segments at least. C. longer than broad. If eighth tergite with more than two hairs and antennæ five-segmented, then p.t. four and one-half to six times as long as base five a.s. and longer than three a.s.

Rhopalosiphum (Koch).

15 (16). Eighth tergite with four to six hairs which are 90 to 100 micro-mm. long.

Antennal and longest hairs on hind tibiæ 70 to 100 micro-mm. Antennæ five-segmented, p.t. four and one-half to six and one-half base five a.s. and one and one-half to two times as long as three a.s. On grass roots, Kenya and Tanganyika. (Part VI, Fig. Z.)
Rhopalosiphum splendens (Theobald).

16 (15). Eighth tergite with only two hairs, which are 10 to 75 micro-mm. long. Longest hairs on three a.s. not exceeding 50 micro-mm.

17 (18). P.t. only one and three-quarters to two and one-half times as long as base of last a.s. Body twice or more as long as antennæ, nine to fourteen times as long as s. On many grasses and maize, a vector of sugar-cane mosaic. Common all over East Africa. Green to very dark olive green. (Figs. H and J.)
Rhopalosiphum maidis (Fitch).

18 (17). P.t. three and three-quarters to five and one-half times as long as base of last a.s. Body five to ten times as long as s.

19 (20). Body two to three times as long as antennæ. U.r.s. one and one-fifth to one and one-half times as long as h.t.2. Antennæ usually five-segmented, very rarely of six segments. Hairs on three a.s. 25 to 40 micro-mm., on hind tibiæ 40 to 65, on eighth tergite 50 to 70 micro-mm. A green aphid feeding at or below ground level. Not known from East Africa. (Part VI, Figs. S–X.)
Rhopalosiphum insertum (Walker).

20 (19). Body one and one-quarter to twice as long as antennæ. U.r.s. nine-tenths to one and one-quarter times as long as h.t.2. Antennæ always six-segmented. Hairs on three a.s. Ten to 20 micro-mm., on hind tibiæ and eighth tergite 25 to 40 micro-mm. A brown aphid feeding on the leaves. In East Africa known only from Njoro and Muguga in Kenya. (Figs. K and L.)
Rhopalosiphum padi (L.).

KEY TO THE ALATÆ OF EAST AFRICAN RHOPALOSIPHINA

1 (2). Dorsal abdominal pattern of transverse, often partially fused (Fig. C), black bars present: c. with 10 to 20 hairs. **Longiunguis sacchari.**

2 (1). No dorsal abdominal pigmentation: cauda with four to eight hairs.

3 (4). S. two-fifths to two-thirds as long as c., one-sixteenth to one-twenty-fifth as long as body. P.t. two and three-quarters to four times as long as base six a.s. Mealy with wax in life.
Hyalopterus pruni.

4 (3). S. as long as or longer than c., if less than one-twelfth as long as body, then p.t. less than two and three-quarter times as long as base of last a.s. Not conspicuously wax-covered in life.

5 (8). Eighth tergite with four to ten hairs, antennæ usually five-segmented.

6 (7). L.a.t. present on first and seventh segments. C. distinctly longer than broad. Hind wing with two oblique veins. P.t. four and three-quarters to six and one-half times as long as base of last a.s. When antennæ five-segmented, p.t. one to one and one-half times as long as three a.s.
Rhopalosiphum splendens.

7 (6). L.a.t. absent. C. little longer than broad. Hind wing with only one oblique vein. P.t. three to four and one-half times as long as base five a.s., one-half to four-fifths of three a.s.
Yezabura rhodesiensis.

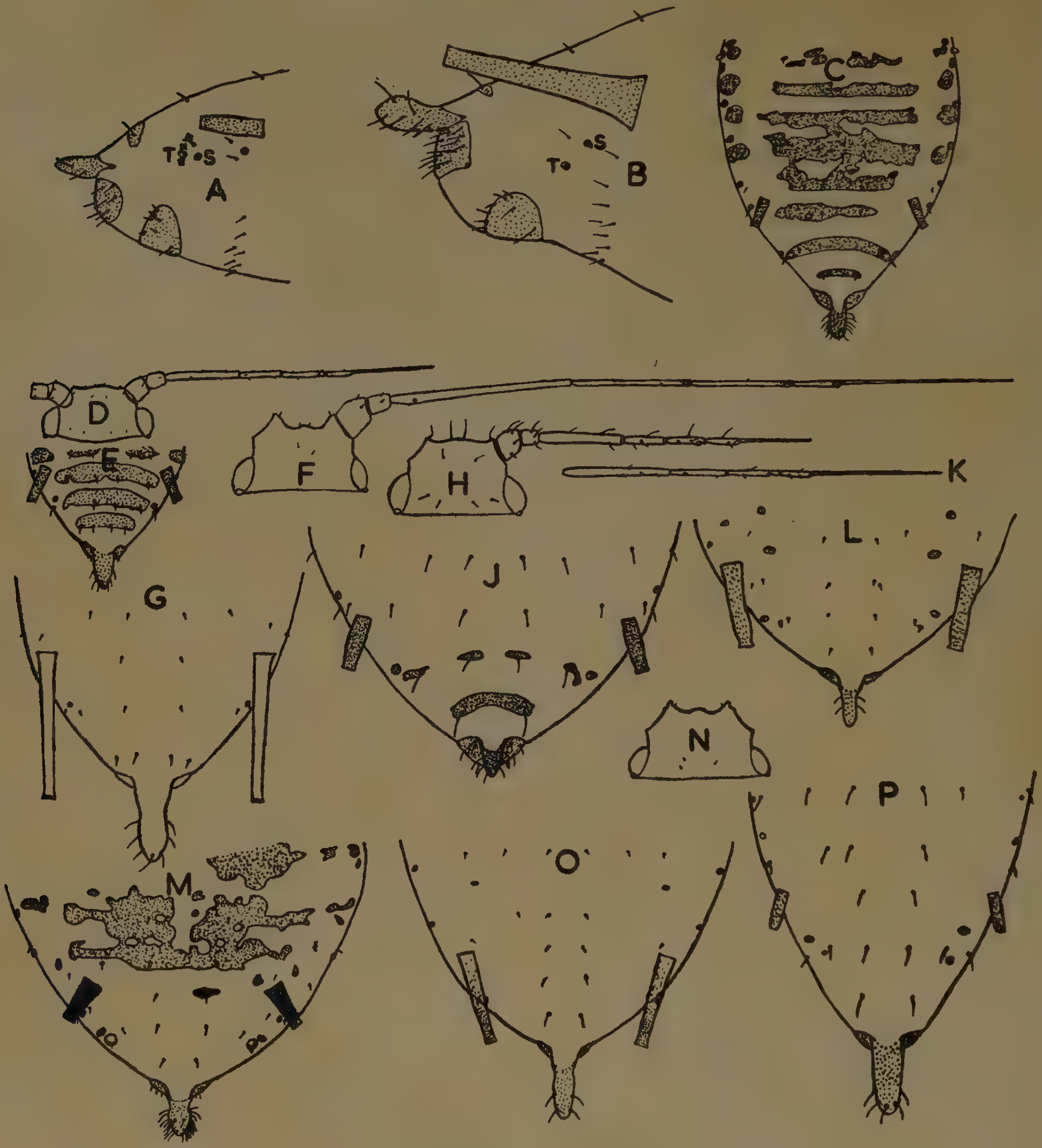
8 (5). Eighth tergite with only two hairs, antennæ usually six-segmented.

9 (10). P.t. one and four-fifths to two and one-half times as long as base of last a.s. Body nine to fifteen times as long as s. Three a.s. with six to thirty rhinaria, four a.s. with nought to twelve. **Rhopalosiphum maidis.**

10 (9). P.t. two and three-quarters to five and one-half base six a.s. Body seven to nine times as long as s.

11 (12). Three a.s. with three to eight rhinaria, four a.s. with nought to one. Media of fore-wing only once branched. P.t. two and three-quarters to three and one-half times as long as base six a.s. Green insect.
Schizaphis graminum.

12 (11). Three a.s. with 13 to 25 rhinaria, four a.s. with two to ten. Media of fore-wing twice branched. P.t. four to five and one-half times as long as base six a.s. Brown insect.
Rhopalosiphum padi.



LEGEND FOR DIAGRAM

A—*Rhopalosiphum maidis*, lateral view of posterior part of abdomen showing lateral tubercle (T) and spiracle (S).

B—*Aphis nerii*, as for A.

C—*Longiunguis sacchari*, abdomen of winged form.

D and E—*Macrosiphum sijui*, D head, E posterior part of abdomen of aptera.

F and G—*Metopolophium dirhodum*, as for D and E.

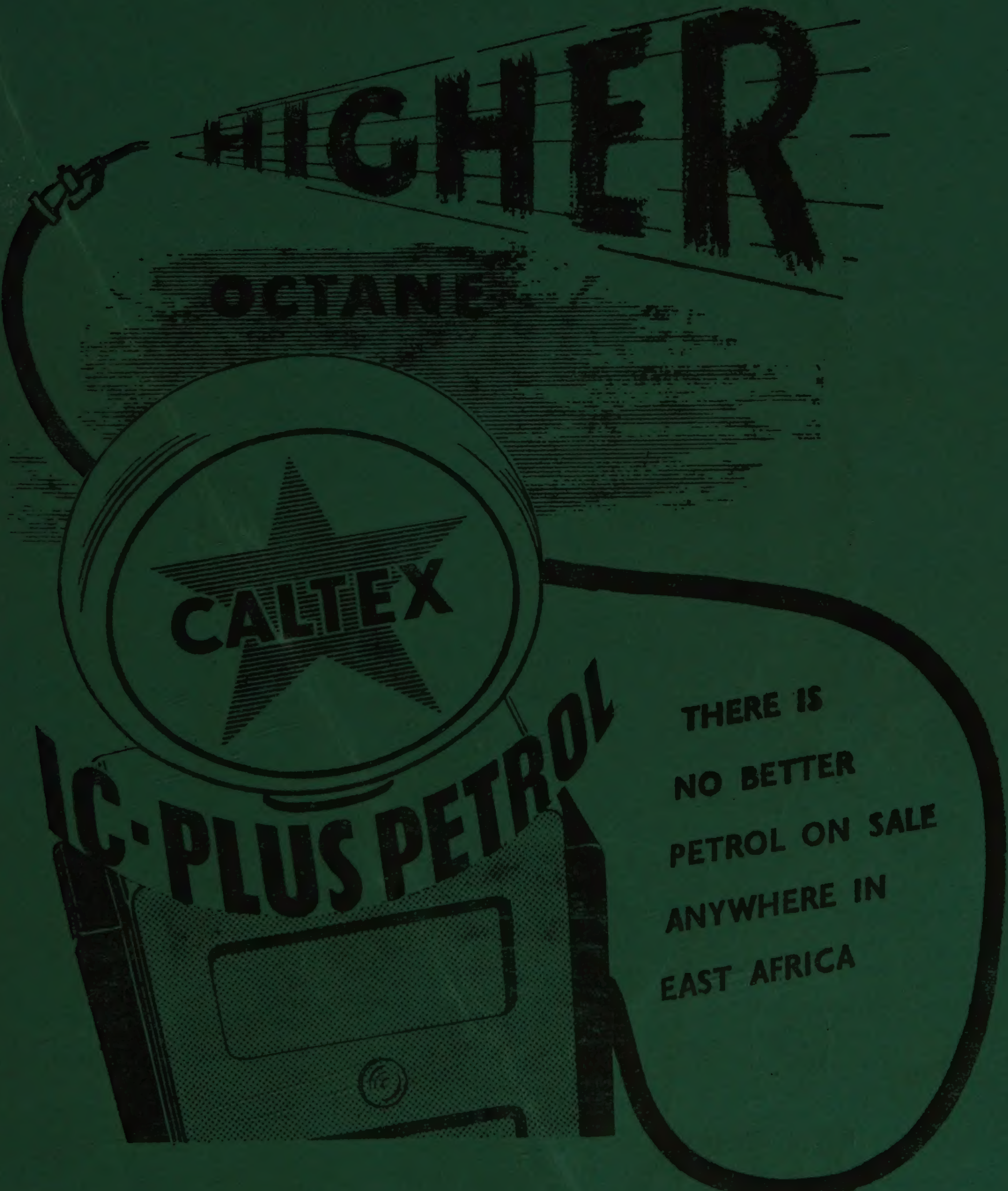
H and J—*Rhopalosiphum maidis*, as for D and E.

K and L—*Rh. padi*, K antenna of aptera, L as for E.

M—*Longiunguis sacchari*, as for E.

N and O—*Schizaphis graminum*, N head of aptera, O as for E.

P—*Hyalopterus pruni*, as for E.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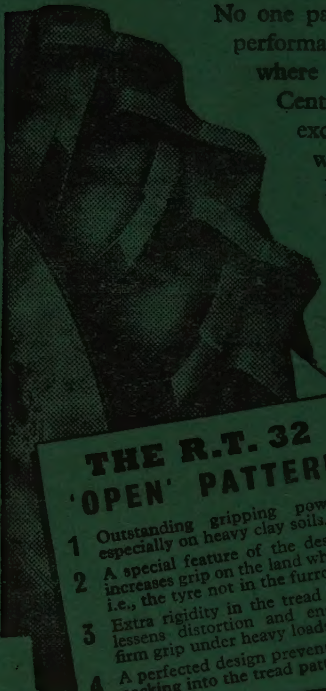

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